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NIST
PUBLICATIONS

**Electronics and Electrical
Engineering Laboratory**

Office of Law Enforcement Standards

**Programs, Activities, and
Accomplishments**



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The Electronics and Electrical Engineering Laboratory

Through its technical laboratory research programs, the Electronics and Electrical Engineering Laboratory (EEEL) supports the U.S. electronics industry, its suppliers, and its customers by providing measurement technology needed to maintain and improve their competitive position. EEEL also provides support to the federal government as needed to improve efficiency in technical operations and cooperates with academia in the development and use of measurement methods and scientific data.

EEEL consists of five programmatic divisions and two matrix-managed offices:

- Electricity Division
- Semiconductor Electronics Division
- Radio-Frequency Technology Division
- Electromagnetic Technology Division
- Optoelectronics Division
- Office of Microelectronic Programs
- Office of Law Enforcement Standards

This document describes the technical programs of the Office of Law Enforcement Standards. Similar documents describing the other Divisions and Offices are available. Contact NIST/EEEL, 100 Bureau Drive, MS 8100, Gaithersburg, MD 20899-8100. Telephone number: (301) 975-2220, On the Web: www.eeel.nist.gov

Cover Caption: The Office of Law Enforcement Standards assists law enforcement and criminal justice agencies through the development of equipment performance standards, standard reference materials, and scientific research. Our logo reflects the type of programs that we conduct: DNA research, arson research, forensic sciences, and law enforcement weapons and equipment. Also shown on the cover is a model of the DNA double helix, an electrophoresis system used in DNA research and identification, and a law enforcement officer using a conventional radar speed measuring device.

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Engineering Laboratory**

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NISTIR 6432

January 2000

U.S. DEPARTMENT OF COMMERCE

William M. Daley, Secretary

Technology Administration

Dr. Cheryl L. Shavers, Under Secretary of Commerce for Technology

National Institute of Standards and Technology

Raymond G. Kammer, Director



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Welcome

The **Office of Law Enforcement Standards (OLES)** helps law enforcement, corrections, and criminal justice agencies ensure that the equipment they purchase and the technologies they use are safe, dependable, and effective. The Office, with a staff of eight, is based in Gaithersburg, Maryland, and is one of the two offices within the Electronics and Electrical Engineering Laboratory at NIST.

OLES was established as a matrix management organization in 1971, and was based on recommendations from the President's Commission on Crime. The Commission report, entitled "Crime in a Free Society," recommended that a federal agency be appointed to assist criminal justice agencies by developing equipment standards and providing technical support and assistance. The report indicated that the then National Bureau of Standards was one such agency up to this task. As a result, the Departments of Commerce and Justice signed a Memorandum of Understanding and the Office was established.

Since that date, **OLES** has fulfilled its mission by applying science and technology to the needs of the criminal justice community, including law enforcement, corrections, and forensic science as well as the fire service. The Office focuses on the development of performance standards, which are promulgated as voluntary national standards by the National Institute of Justice (NIJ), the research arm of the Department of Justice (DOJ). **OLES** also conducts studies that result in the publication of technical reports and user guidelines.

NIJ is the primary sponsor of **OLES** projects. Projects are and have also been supported by the National Highway Traffic Safety Administration (NHTSA), the Federal Bureau of Investigation (FBI), and the Office of Management and Budget (OMB).

OLES conducts research on protective clothing, communication systems, emergency equipment, investigative aids, protective and enforcement equipment, security systems, traffic enforcement systems, vehicles, weapons and ammunition, and analytical techniques and standard reference materials used by the forensic science community. The composition of **OLES** projects varies depending on the priorities of the criminal justice community at any given time, and, as necessary, draws upon the resources of EEEL, NIST divisions external to **OLES**, and outside agencies.

To help law enforcement, corrections, and criminal justice agencies acquire the high-quality resources that they need to do their jobs, **OLES**:

- Develops methods for testing equipment performance;
- Develops methods for examining evidentiary materials;
- Develops standards for equipment and operating procedures;
- Develops standard reference materials; and
- Performs other scientific and engineering research as required by NIJ.

The NIJ-sponsored activities are managed by **OLES** as part of an overall Law Enforcement and Corrections Standards and Testing Program that includes the development of standards and test protocols, the testing of equipment, and the publication of test results. For example, the Public Safety Communications Standards Program resulted in the development

of standards for communication systems items such as portable transceivers, base stations, mobile digital equipment, and surveillance devices. The Weapons and Protective Systems Program developed standards for revolvers and semi-automatic pistols, shotguns, body armor, protective helmets, and handcuffs.

OLES has published, mostly through NIJ, more than 200 standards, guides, and technical reports over its 28-year history. These publications have dealt with such topics as emergency vehicle warning devices, police clothing and equipment, components of intrusion alarm systems, physical security of door and window assemblies, metal and explosive vapor detectors, arson accelerant detectors, and narcotic test kits. **OLES** also developed standard reference materials for glass comparisons and DNA profiling and reference collections of automobile paints and synthetic fibers for use by forensic laboratories.

For additional information about the Office of Law Enforcement Standards, please visit our web sites at <http://www.eeel.nist.gov/810.02> or <http://www.nlectc.org>.

Mission

The mission of **OLES** is to serve as the principal agent for standards development for the criminal justice and public safety communities. **OLES** has been instrumental in the development of numerous standards and the issuance of various technical reports that have had significant impact on both of these communities. Through its programs, **OLES** helps criminal justice and public safety agencies acquire, on a cost-effective basis, the high quality resources they need to do their jobs. To accomplish this task, **OLES**:

- Develops methods for testing equipment performance;
- Develops methods for examining evidentiary materials;
- Develops standards for equipment and operating procedures;
- Develops standard reference materials; and
- Performs other scientific and engineering research as required by the criminal justice and public safety communities.

Vision

The vision of **OLES** is to apply science and technology to the needs of the criminal justice community, including law enforcement, corrections, forensic science, and the fire service. While the primary focus is on the development of minimum performance standards, which are promulgated by the sponsoring agency as voluntary national standards, **OLES** also undertakes studies leading to new technology development and evaluations, new measuring science protocols, new standard reference materials and standard reference collections for application to the criminal justice system, and the issuance of technical reports and user guidelines.

Values

OLES values its commitment to serve the public safety community in acquiring, on a cost-effective basis, the high-quality resources they need to do their jobs to meet the needs of the criminal justice system. The Office values its collaboration with the national law enforcement technology centers, forensic community, and all segments of the of the criminal justice community. It strives to understand the needs of the community it serves and strives to meet their needs keeping in mind the limited funds at their disposal. **OLES** advocates the needs of the public safety community to the scientific community and encourages the adaptation of available technologies so that these needs can be met.

Weapons and Protective Systems

Technical Contacts:

Kirk Rice
Carter Lord
Alim Fatah

Staff-Years:

4.6 professionals
1.0 technician

Funding Sources:

Other Government Agencies
(100%)

Project Champions:

- Armor & Protective Systems Working Group
- EEEL, Electricity Division, Electronic Instrumentation and Metrology
- Home Office, Police Scientific Development Branch (PSDB), United Kingdom
- Institute of Surgical Research, Brooke Army Medical Center, San Antonio, TX
- National Law Enforcement and Corrections Technology Center, Rockville, MD
- National Technical Systems, Fredericksburg, VA
- Office of Special Technology, Technical Support Working Group (TSWG), Ft. Washington, MD
- Touchstone Research Laboratory, Ltd., Triadelphia, WV
- University of Virginia, Charlottesville, VA
- U.S. Army Aberdeen Test Center (ATC), Aberdeen, MD
- U.S. Army Soldier Systems Command, Natick, MA
- U.S. Secret Service, Washington, DC

Project Goals

To manage programs, direct and conduct research, develop test plans, oversee and monitor test and evaluation efforts, and develop performance standards, guidelines and reports to advance the technologies of weapons, protective equipment, and ammunition in support of the goals and priorities of both NIST and the outside agency sponsors.

Technical Strategy

The Office of Law Enforcement Standards conducts and monitors programs that are concerned with establishing performance standards for weapons and protective equipment used by law enforcement and corrections personnel. In some cases, existing standards are revised to reflect the state of technology or to improve the test methodology. The standards in this area that are being revised or studied in FY-00 are as follows:

- Ballistic Resistance of Body Armor
- Ballistic Resistant Protective Materials
- Ballistic Helmets
- Metallic Handcuffs
- Riot Helmets and Face Shields

In other cases, it is necessary to develop new standards or test protocols to meet newly established needs. Programs in this area for FY-00 are as follows:

- Stab-Resistant Body Armor
- Protective Gloves
- Evaluation of Smart Guns
- Armored Car Standard
- Holster Standard

OLES is developing a state-of-the-art Ballistics Research Test Facility specifically for addressing weapons, ballistics, and protective equipment issues for the law enforcement and corrections community.

OLES also conducts and participates in studies that may ultimately advance weapons and protective equipment technologies. Efforts underway in FY-00 are as follows:

- Study of Head Injuries during Ballistic Loading of Helmets

- Body Armor Trauma Plates
- Evaluation of an Optoelectronic Method to Measure Ballistic Deformation of Body Armor
- Accelerated Aging of Armor Materials and Armor
- Further Development of the Relative Impact Factor (RIF)

OLES also provides technical consultation to law enforcement and corrections personnel and the general public in areas related to equipment selection, ballistics, performance issues, training, etc.

Update of NIJ Standard-0101.04, "Ballistic Resistance of Body Armor"

Law enforcement and corrections agencies rely on the NIJ Standard to ensure the quality and reliability of their bullet resistant vests. As new developments occur, such as new materials and changing ballistic threats, the standard is updated on a regular basis to respond to these changes.

NIJ Standard-0101.04, "Ballistic Resistance of Personal Body Armor," is a general revision to NIJ Standard-0101.03, "Ballistic Resistance of Police Body Armor," and is due to be released in early calendar year 2000. For the remainder of FY-00, several issues not addressed by this latest revision of the standard will be researched. Some of the on-going projects include: aging and environmental effects on armor performance and service life, blunt trauma research, threat assessment methods, and new material evaluation. OLES will monitor work being performed under contracts issued through the Technical Support Working Group (TSWG), an interagency group headed by the U.S. Navy's Office of Special Technology in the areas of blunt trauma research and body armor aging. Additional research will be conducted on the Relative Impact Factor, which is an empirical method to estimate the penetration capability of a bullet fired into body armor.

MILESTONES: During FY-00, OLES will address comments and concerns from law enforcement and industry regarding the latest revision to NIJ Standard-0101.04. OLES will revise the standard as appropriate so that it is current with the latest technologies and recommended test methodologies. The final product, i.e., a revised standard, will probably not be ready until FY-01/02, depending upon the schedule of supporting studies.

Update of NIJ Standard-0108.01, "Ballistic Resistant Protective Materials"

In the area of personnel protection, many types of materials are employed to protect the user from ballistic threats. These materials can be found in shields, vehicle armor, and transparent bullet-resistant materials. NIJ Standard-0108.01 establishes minimum performance requirements and methods of test for these protective materials. This standard is due to be revised in FY-00.

To date, test methodologies that estimate the ballistic limit, that is, the velocity at which a ballistic resistant material is expected to fail 50 % of the time, have been examined. A preferred method of determining this ballistic limit has been identified. Some preliminary tests have been performed to identify specific needs of the testing program. As part of this effort, it is expected that the same threat ammunition that was adopted under the effort to revise NIJ Standard-0101.03, "Ballistic Resistance of Police Body Armor," will likewise be adopted for this revision to NIJ Standard-0108.01.

MILESTONES: A new revision to NIJ Standard-0108.01 will be issued. It will include 1) ballistic limit testing; 2) adoption of the same threats as defined for NIJ Standard-0101.04, "Ballistic Resistance of Personal Body Armor;" 3) improvements in the area of test quality assurance by specifying the use of formal test procedures and normalized compliance test report forms; and 4) any special provisions for testing transparent materials.

Update of NIJ Standard-0106.01, "Ballistic Helmets"

Law enforcement agencies rely on the NIJ Standard "Ballistic Helmets" to ensure the quality and reliability of their bullet resistant helmets. As new developments take place, such as new materials and changing ballistic threats, the standard is updated on a regular basis to respond to these changes.

Several items will be addressed in the revision to this standard, including: expansion of ballistic threat levels consistent with NIJ Standard-0101.04; revision of the impact measurement system for performance testing; and re-evaluation of baseline performance requirements. Additionally, we will continue to monitor and participate in a research program underway at the University of Virginia, in which the effect of head trauma is

being studied as a result of ballistic loads applied to helmets. Significant findings from that effort will be evaluated for potential inclusion in this or future revisions of NIJ Standard-0106, "Ballistic Helmets."

MILESTONES: In FY-00, NIJ Standard-0106.01 standard will be revised. It will address the issues listed above and offer improvements in the area of test quality assurance by specifying the use of formal test procedures and normalized compliance test report forms. It will benefit from the same improvements that were made in NIJ Standard-0101.04, "Ballistic Resistance of Personal Body Armor," including ballistic limit testing and adoption of the same threats.

Update of NIJ Standard 0307.01, "Metallic Handcuffs"

The classic mass-produced steel handcuff, little changed over the last 90 years, is used for arrests and for prisoner transport. The limitations of traditional handcuffs become evident, particularly during the transport of prisoners, where prisoners have been known to pick the double lock with a bit of wire; or defeat the pawl directly with a piece of thin material; or break the "cheek plates" apart at the ratchet pivot.

OLES has been conducting an investigation into handcuff design parameters and performance test options. A force-torque apparatus for evaluating loads applied to typical handcuffs was developed. A theoretical analysis describing the handcuff components as curved beams was developed and used to examine the way in which the stiffness of those "beams" depends on shape and material composition. The analytical results are being evaluated and may be particularly useful for improving traditional handcuff designs.

A contract with Touchstone Research Laboratory addresses design details and shortcomings including: longitudinal testing of handcuffs having no tongues on the cheek plates; factors affecting the picking of handcuff locks; and handcuff size issues.

MILESTONES: A draft revision of the handcuff standard is being prepared. Discussion and editing of the draft revision will extend into FY-00.

Riot Helmets and Face Shields

NIJ Standard-0104.02, "Riot Helmets and Face Shields," was last reviewed in October 1984. Since that time the safety equipment testing industry as well as the American

Society for Testing and Materials (ASTM) and the American National Standards Institute (ANSI) have switched to “headforms” endorsed by the International Organization for Standardization (ISO) for all protective headgear testing. OLES has received over the past few years many complaints from the safety equipment testing laboratories about the lack of availability of the “headform” specified in the NIJ Standard and that this NIJ Standard is not conforming to the adoption of International Standards wherever feasible.

To address these concerns, OLES will begin a standard review process to identify: 1) whether upgrading the identified threat levels covered in the current standard is necessary and; 2) whether changing to an ISO “headform” will change the protection levels covered under the old standard. If changes are necessary, revised test procedures will be developed and validated. The changes will be issued in a revised standard.

MILESTONES: During FY-00, any potential changes to the standard will be determined, revised test procedures will be validated with extensive testing, and findings will be summarized in a technical report.

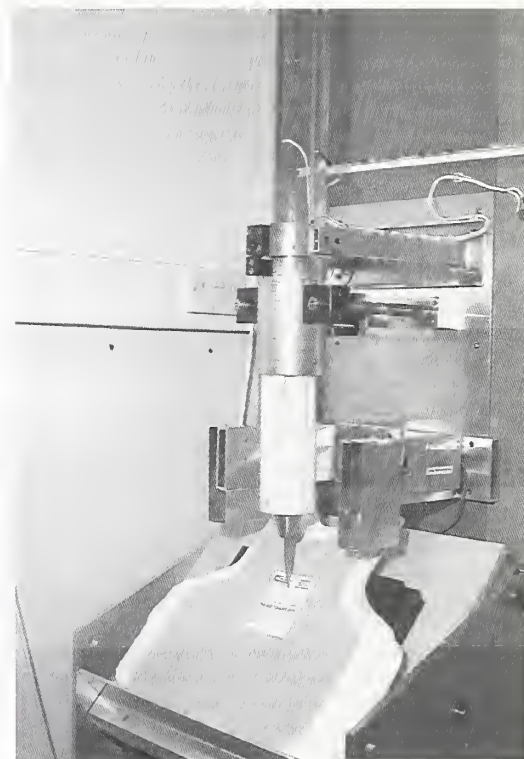
Standard for Stab Resistant Body Armor

The ballistic threat to law enforcement and corrections personnel is addressed through NIJ Standard 0101.03 (soon to be 0101.04), Ballistic Resistance of Police Body Armor. One particular threat category not covered by the Ballistic Resistance standard is that from sharp and edged weapons. The stab and slash threats posed by these weapons represents the primary threat to corrections officers and a secondary threat to police officers in the U.S. Currently, there is no NIJ standard addressing the performance requirements of body armor subjected to these threats.

Several body armor manufacturers have begun to market armor capable of resisting knife and ice pick attack. With no NIJ standard for stab resistance, the law enforcement and corrections communities are left either to decipher what a vendor means by stab resistance, or to develop their own “in-house” guidelines.

Research on this project has taken place through a collaborative effort between OLES and the U.S. Secret Service in the United States and the Police Scientific Development

Branch (PSDB) in the United Kingdom (U.K.). Through an agreement with and funding from the TSWG, PSDB performed most of the experimental work supporting this effort at their location in Sandridge, U.K., and at the Royal Military College of Science at Shrivenham, U.K. PSDB developed a test apparatus to accurately simulate the blow delivered by a knife wielding assailant, as well as a method for assessing relative sharpness of blades.



OLES stab test apparatus used to support development of NIJ body armor standard for stab resistance.

There are several areas that need further attention. For example, a spike threat may be more appropriate for body armor used in correctional facilities. Research will continue in this area. To support standards development, a drop-test rig and knife sharpness tester are operational at our Ballistics Research Test Facility (BRTF).

MILESTONES: In FY-00, OLES plans to: 1) define an ice-pick blade; 2) conclude validation testing; 3) finalize draft and issue standard; 4) assist with evaluation and certification of potential test laboratories; and 5) assist with establishing a formal Compliance Test Program.

Protective Gloves Test Protocol

Law enforcement and corrections personnel routinely face the threat of injury to hands from exposure to needles, knives, and other sharp objects. Puncture and slash resistant gloves offer protection from many of these threats.

To ensure that gloves will meet the performance expectations of the user, a formal test protocol was developed. The protective glove test protocol was issued in June 1999 as NIJ Test Protocol 99-114, "Test Protocol for Comparative Evaluation of Protective Gloves for Law Enforcement and Corrections Applications." In the meantime, the National Law Enforcement and Corrections Technology Center (NLECTC) has put out a solicitation for bids from qualified test labs. The bids have been received and are now being evaluated. Provided they pass the formal qualification process, these labs will become qualified to do commercial glove testing in accordance with NIJ Test Protocol 99-114.



Samples of protective gloves.

MILESTONES: OLES will participate in the evaluation of bids in early FY-00. After that, we will make site visits and witness and evaluate the test procedures implemented at the laboratories.

Test Protocol for Evaluation of Smart Guns

As evidenced by recent news stories, there has been a concern with regard to safety of handguns for two main reasons: law enforcement officers are killed by criminals using the officers' own guns; and children are accidentally killed with guns they find at home or elsewhere.

Because of these problems, Congress requested the U.S. Department of Justice (USDOJ) to investigate ways of increasing handgun safety. Specifically, the request was to make guns childproof and also to ensure law enforcement officers' guns cannot be fired by criminals, but only by the personnel to whom the gun was legally issued. The National Institute of Justice awarded a contract to a major gun firearms manufacturer to develop a "Smart Gun" prototype. After several years of R&D, the manufacturer has developed a prototype of the "Smart Gun."

Several other companies have developed versions of "Smart Guns" which need to be evaluated. However, before NIJ can endorse any of these smart guns, comprehensive laboratory testing at OLES, as well as limited field-testing of concept prototypes is necessary.

MILESTONES: Planned efforts for FY-00 include preparing a plan for comprehensive laboratory testing of the candidate "smart guns." This will take place initially at the OLES BRTF and will possibly include follow-on work which would result in the development of an NIJ Standard with an integrated test procedure for use in testing and certifying compliance. Additionally, a plan will be formulated to implement limited field testing of prototype smart guns at participating law enforcement agencies.

Armored Car Standard

There currently is no U.S. standard describing the ballistic resistance of armored cars used for diplomatic protection. As a result, there have been instances where vendors have advertised their armored cars as being able to defeat certain types of threats. Field tests have shown some of these claims to be false. To rectify this situation, a uniform standard is needed that clearly defines the types of threats being tested and the test methods.

This standard must also consider that other performance parameters, including acceleration, braking, handling safety, are also of paramount importance. To address these issues, OLES is beginning a program to develop a draft standard that will be promulgated by NIJ to establish minimum performance requirements and methods of test for armored cars that are used for diplomatic protection. This work will be performed in close coordination with other agencies that are concerned with diplomatic protection, such as

the U.S. Secret Service, the Department of State, and the Department of Defense.

MILESTONES: *In early FY-00, we will evaluate a preliminary test protocol. By mid FY-00, a draft standard will be developed and subjected to further field validation tests during the remainder of FY-00. By FY-01, a final draft standard is expected.*

Holster Standard

The advancement in holster design has been unprecedented in recent years, and the development and use of "security" type holsters may well be a factor in the general reduction in the number of officers killed by their own guns in the past several years. Manufacturers have developed a preliminary ranking system, which designates holsters as Level I, II, or III retention holsters. This ranking effectively evaluates the difficulty encountered by someone other than the officer in removing his gun from the holster. There is also an increased difficulty for the officer to draw his gun as the retention level increases, resulting in the need for an increased amount of training and practice to become proficient.



Holster retention systems for law enforcement officers have saved lives.

To standardize the definitions of retention, NIJ has indicated a need for an NIJ Standard for Law Enforcement Holsters. The first step in the development of a meaningful Law Enforcement Holster Standard is to contact the manufacturers of holsters and determine the methods they employ to design and evaluate the quality, durability, reliability, and security of their holsters. Information will also be

gathered from law enforcement agencies, primarily to identify problems with holsters, and identify the types of holsters which need to be addressed by the standard (i.e. Duty-Patrol, Duty-Detective, Duty-Bicycle, Off-Duty, Undercover, etc.). With this information, a draft standard for Law Enforcement Holsters will be prepared, including a formal test procedure designed to evaluate all pertinent performance aspects of the holster to be used by law enforcement.

The OLES force-torque apparatus will be evaluated to determine if it is useful for characterizing the forces necessary to defeat various holster retention levels. Once the draft standard has been completed and preliminary validation tests conducted, the draft standard will enter the standard review process for comments from the manufacturers and law enforcement community. Comments will be reviewed and incorporated as appropriate, and a final draft of the standard will be submitted for promulgation.

MILESTONES: *In FY-00, information will be collected from manufacturers regarding the retention level ranking systems they use. Additionally, the applicability of utilizing the force-torque apparatus will be investigated and a determination made as to its suitability as an evaluation method. A draft of the standard will be developed.*

Study of Head Injuries during Ballistic Loading of Helmets

This study will support the update of NIJ Standard-0106.01, "Ballistic Helmets." The U.S. Army has a requirement to provide ballistic head protection to its combat troops utilizing newer, lightweight, ballistic resistant material systems. It is anticipated that the forces transmitted by successfully defeating impacting rounds with decreasingly lighter weight helmet systems may cause adverse effects to the individual's head.

OLES and the U.S. Army Soldier Systems Center will collaborate in an attempt to assess the limiting performance of helmets and to define risk of injury criteria that will prevent head injury from 9-mm ballistic impacts. The testing will be done through an R&D contract with the University of Virginia and will utilize the expertise and facilities at the Institute of Surgical Research at Brooke Army Medical Center in San Antonio, TX. As part of this study, the validity of the NIJ Standard-0106.01 acceleration limit will be assessed; and if

necessary, improvements to the “Ballistic Helmets” standard will be recommended.

Correlation of forces recorded on an instrumented test device with anticipated physical effects on individuals is key to the development of improved, lighter weight, energy absorbing, protective, helmet systems. The ability to validate the existing NIJ helmet standard or establish a standard ballistic test method which can discriminate marginal from acceptable ballistic protective helmets is key to the successful transfer of technology to the law enforcement community.

MILESTONES: *OLES will monitor the study, participate in scheduled reviews, and assist with tests as necessary.*

Study of Body Armor Trauma Plates

Soft body armor has proven very effective in lessening the severity of injuries to law enforcement and corrections personnel; however, the possibility still exists for behind-armor blunt trauma. To defeat a bullet, modern soft body armor is constructed of materials that deform to effectively stop a bullet without allowing it to penetrate the body. This deformation can lead to blunt trauma injury. To prevent these kinds of injuries, some manufacturers have incorporated “trauma plates” into their armor designs. With the advent of trauma plates, there are questions about whether the plates themselves pose any kind of fragment hazard to the wearer and whether the test methodologies must be modified to properly evaluate the performance of both the soft armor and the trauma plate.

OLES is collaborating with other groups through the Technical Support Working Group to study these issues identified above. These efforts will lay the groundwork for determining the performance characteristics that are most relevant to the users’ needs and for developing or adapting test methods to evaluate trauma plates. Validation testing and establishment of a formal test program are planned. Significant results from these studies will be incorporated in a future revision of the “Ballistic Resistance of Personal Body Armor” standard.

MILESTONES: *In FY-00, we will monitor the backface deformation research and the blunt trauma literature survey being sponsored by the TSWG. A test method will be identified and validated through testing, and incorporated into a future*

revision of the “Ballistic Resistance of Personal Body Armor” standard.

Evaluation of an Optoelectronic Method to Measure Ballistic Deformation of Body Armor

Ballistic deformation of body armor after impact with a high-velocity bullet is assessed by observing the backface deformation of a backing material made of clay or ballistic plastic. The measurement method typically uses clay as the backing material, and deformation is defined as the maximum momentary displacement of the back surface of the armor. The maximum displacement is further described as the depth depression in the backing material.

The clay used for these studies is inexpensive but must be reformed after each projectile impact. Because the clay must be reformed after each impact, the test procedure is very slow, labor intensive, and not amenable to automation. Ballistic plastic is an alternative to the clay, but the plastic is very expensive and is limited to a few projectile impacts before it must be replaced. Consequently, this material also does not lend itself for use in an automated measurement system.

Furthermore, the present measurement method does not provide information on the force or energy imparted to the backing material and, consequently, does not provide information on the effect of the impact on a person.

To address these deficiencies, a study will be undertaken to examine the feasibility of using optoelectronic methods to measure the time history of projectile-induced deformation of a backing material. If successful, this work will be the basis for the development of an automated system for measuring the energy and force imparted to a backing material through a ballistic vest. The time history of the depression will be measured by observing the change in transmitted light as the optically opaque body armor pushes into the optically transparent backing material.

Identifying a suitable backing material will require contacting manufacturers and testing candidate materials. Testing will consist of performing impact events at the OLES test range and then making optical transparency measurements using a suitable laser in the Electricity Division laboratories. Mechanical

property changes will be noted by comparing deformation under static conditions.

MILESTONES: *Evaluate proposed methods for feasibility and applicability to measuring behind armor effects of ballistic impact, and submit recommendations.*

Accelerated Aging of Armor Materials and Armor

Since the beginning of the general use of ballistic resistant material for police body armor, the question of how long does the armor last has been of prime interest to law enforcement agencies and armor manufacturers alike. The effective service life of armor is important for the protection of the officer as well as to minimize liability issues. Premature replacement of armor represents a significant expenditure of funds unnecessarily.

To determine the effective life of armor in a reasonable period of time, the practice of accelerated aging will be employed. Carefully controlled environmental conditions as well as realistic physical stresses will be repetitively applied to specific samples of armor material as well as complete sets of armor. The Ballistic Limit as defined in NIJ Standard-0101.04 will be employed to evaluate the degradation of the ballistic resistance of the armor and armor material. On completion of the study, a formal test report will be written and submitted for NIJ review and promulgation.

MILESTONES: *Test procedure will be prepared, and arrangements made for a test laboratory to conduct accelerated aging tests. A formal technical report based on results of the tests will be submitted for NIJ promulgation.*

OLES Ballistics Range Improvement and Operation

OLES is responsible for a small ballistics test laboratory located in an abandoned NIKE missile silo just outside the NIST complex in Gaithersburg, MD. This facility was originally developed to allow OLES personnel to conduct various weapons, ammunition, and protective armor tests to support and validate its development of testing standards for those articles. In addition, OLES participates in numerous domestic and international forums and efforts associated with similar standards research and development which result in outside test participation requests and solicitations.

The availability and use of this facility is important to the mission of OLES, in that it permits the Office to empirically investigate and validate the methodologies it develops for its test standards. The ability to rapidly and critically investigate test standards as well as conduct other test programs that require OLES participation/qualification is a critical element of the office's mission. An inability to conduct its own studies limits the effectiveness of OLES, and impacts its credibility with industry and law enforcement. It is therefore critical that the facility be improved as part of the OLES infrastructure.

MILESTONES: *In FY-00, the capabilities of the existing range facility will be enhanced by the addition of equipment to permit formal autoloading pistol testing, completion of facilities to permit levels III and IV armor testing, and ballistic limit testing. Additionally, work will continue on the proposed new Ballistics Research Test Facility, to include second generation concept drawings, and schedule and cost estimates.*

Accomplishments

- *Established body armor stab test facility.* In collaboration with the Police Scientific Development Branch in the U.K., a drop test stab fixture and knife sharpness tester are operational at the Ballistics Research Test Facility. This facility will be used to complete work on the Stab Resistance standard.
- Submitted final draft of Revision A to NIJ Standard-0112.03, "Autoloading Pistols for Police Officers," for publishing by NIJ sponsor; and participated in the selection and certification of laboratories to perform the testing. This standard forms the basis of a new pistol performance testing program in which each pistol is carefully inspected for defects, flaws and deficiencies, and is then submitted to a rigorous firing test to assure reliability and safety. Many new models of autoloading pistols have been tested to this new standard at two approved independent laboratories.
- Latest revision to "Ballistic Resistance of Personal Body Armor" body armor standard under final review and due to be published in FY-00. This standard addresses new threat ammunition, testing methods and procedures, and will assure the continued excellent reputation of the NIJ Body Armor Testing Program.
- *Established OLES Ballistic Research Test Facility (BRTF).* Reconfigured a NIKE

missile pit into an effective Ballistics Research Test Facility. This facility provides the ballistics research and test capabilities for OLES and NIJ until completion of a planned, dedicated state of the art Ballistics Research Test Facility at NIST.

- BRTF utilized to obtain residue from gunshots in support of NIST's Chemical Sciences and Technology Laboratory (CSTL) project. Prepared and fired several hundred test rounds at the newly completed BRTF in support of a gunpowder residue project conducted by NIST's CSTL. This research is intended to determine the feasibility of identifying specific ammunition from the residue remaining on the body and clothing of gunshot victims.

- OLES Informational Brief on Safe Gun Storage will become the basis for informational brochure to be distributed by the Office of the Attorney General. This brief, which discusses the conditions and options available for the safe storage of all types of firearms, is expected to become the basis of a brochure to be widely distributed to plainly and clearly discuss the issue of safe gun storage to the general public.

- *Issued NIJ Test Protocol 99-114, "Test Protocol for Protective Gloves for Law Enforcement Applications," June 1999.* This test protocol is the culmination of over two years of effort, working with users, glove manufacturers and standards organizations such as ASTM, ANSI, British Standards Institute (BSI), and the European Committee for Standardization (CEN). Now that the test protocol is completed, NLECTC will initiate a national voluntary testing program of protective gloves and make the results available to law enforcement and corrections agencies to help them make informed decisions when procuring protective glove for their officers.

Publications

NIJ Standard 0112.03, Autoloading Pistols for Police Officers, November 1998.

NIJ Standard 0112.03A, Autoloading Pistols for Police Officers, Revision A, July 1999.

NIJ Test Protocol 99-114, Test Protocol for Comparative Evaluation of Protective Gloves for Law Enforcement and Corrections Applications, June 1999.

Technical Contact:

A. George Lieberman

Staff-Years:

9.0 professionals

Funding Sources:

100% Other Government Agencies

Project Champions:

- Building and Fire Research Laboratory (BFRL), Office of Applied Economics
- EEEL, Electricity Division:
 - Electrical Systems
 - Electronic Instrumentation and Metrology
 - Fundamental Electrical Measurements
- EEEL, Radio-Frequency Technology Division:
 - Radio-Frequency Electronics
 - Radio-Frequency Fields
- EEEL, Electromagnetic Technology Division, Cryoelectronic Metrology
- Federal Bureau of Investigation (FBI), Engineering Research Facility, Quantico, VA
- Home Office, Police Scientific Development Branch (PSDB), United Kingdom
- Independent Testing and Consulting, Inc., Eaton Rapids, MI
- Information Technology Laboratory (ITL), Mathematical and Computational Sciences Division
- Manufacturing Engineering Laboratory, Automated Production Technology Division
- Royal Canadian Mounted Police, Ottawa, Ontario, Canada
- University of Maryland, College Park, Center for Automation Research, College Park, MD
- University of Texas at Dallas (UTD), The School of Human Development, Richardson, TX

Detection, Inspection and Enforcement Technologies

Project Goals

To manage programs, direct research and development efforts, and develop performance standards, guidelines and reports for equipment for detection, inspection, and enforcement in support of the goals and priorities of both NIST and the outside agency sponsors. To provide technical support to the traffic enforcement system as administered by the National Highway Traffic Safety Administration (NHTSA) and the International Association of Chiefs of Police (IACP).

Technical Strategy

Detection, inspection and enforcement technologies employed by law enforcement to safeguard civilians in and about public premises and on our roads and national highways are investigated. To promote cost effective purchases of equipment by the law enforcement community, OLES develops and publishes technical reports, equipment guides, and standards. To evaluate and test equipment, OLES also creates performance specifications and reference artifacts. Representative technologies in this program area currently investigated include: devices for imaging and detecting concealed weapons, detectors for locating electronically detonated bombs, improved surveillance cameras, human and vehicle recognition systems, and x-ray systems for bomb disarmament. To promote safe roads, OLES works with NHTSA and the IACP to develop performance specifications and procedures for testing radar, lidar, and photoradar speed enforcement devices. OLES also works on emergency vehicle warning-light systems and sirens, and has developed computer software to aid police fleet managers to select and purchase patrol vehicles, to estimate expected repair costs, and to make vehicle disposal/replacement decisions.

Development of Systems to Evaluate Magnetic Fields Produced by Walk-Through and Hand-Held Metal Detectors

Walk-through (WT) and hand-held (HH) metal detectors, primary tools used in security screening applications, produce time-varying magnetic fields that may cause personal medical devices (PMEDs) such as cardiac defibrillators, infusion devices, or spinal cord stimulators to malfunction. If an affordable magnetic field emulator can be developed, PMED manufacturers would be able to test devices for interferences from WT and HH devices, and the Federal Drug Administration (FDA) could assess interference thresholds and issue regulatory susceptibility standards for PMEDs.

MILESTONES: By end of FY-01, design and construct one prototype emulator for WT detectors and another for HH detectors.

Terahertz-Wave Concealed Weapon Imaging and Detection System Development

The Law Enforcement and Corrections Technology Advisory Council (LECTAC) has listed concealed weapon detection and imaging as their top law enforcement and corrections (LEC) priority. Present metal weapon detectors are inadequate because of their limited range (less than 15 cm for a hand-held device and less than 0.5 m for a walk-through device) and form (hand-held device is a wand and the walk-through is a portal). Presently, there is no system that can be used as a portable long-distance concealed weapon viewer. Furthermore, the ambiguity of simple detection presents liability issues for subsequent search.

MILESTONES: By end of FY-00, assess possible illumination and detection options, and design, develop and fabricate a hybrid detector.

Improved Handgun Replica for Test and Evaluation of Hand-Held (HH) and Walk-Through (WT) Metal Detectors

To ensure that WT and HH metal detectors function properly requires the metal detectors to exhibit positive detection of threat objects, i.e., weapons (such as handguns, knives, razor blades) or other objects that can be used to defeat security restraints (such as handcuff keys or paper clips). Actual threat items

cannot be used as test objects because variability of manufacture would not allow measurement reproducibility. Therefore, threat object replicas having well-defined material composition and dimensional sizes and tolerances must be used. Unlike most threat objects, the handgun has a complex shape and consists of several metals.

MILESTONES: By end of FY-00, identify minimally detectable handguns for use as exemplars. By the end of FY-01, design accurate replicas (based on the exemplars) for testing WT and HH metal detectors.

Detection of Electronic Bomb-Detonators

In 1997, OLES undertook support of a two-year program to study the feasibility of electromagnetic detection of electronic bomb detonators. Hidden explosives often have electronic timing devices that must operate continuously up to the time of detonation. These timing devices radiate unintentional signals that could make them amenable to electromagnetic detection. The ability to detect bombs with electronic detonators could have a major impact against terrorism. Such detection systems could be deployed at airports, subway stations, highways, and various public places.

MILESTONES: By April 2000, provide a final report on the design of a dipole array antenna and experiment to determine detection range and feasibility.

Measurement of Electrical Properties of Metals Used in Hand-Held (HH) Weapons

The law enforcement community has demanded improved detection performance, performance tests, and performance specifications for the hand-held (HH) and walk-through (WT) metal detectors. These demands have resulted in performance tests that are more complex, time-consuming, and costly than previous test procedures. To allay the cost of tests for development of more complicated metal detection systems and to expedite the development of these systems, it is important to have reliable data on the electromagnetic properties of weapon-grade metals from which to perform computer simulations of detector performance. Reliable conductivity and permeability measurements of many metals used for weapons do not exist in the literature.

MILESTONES: By end of FY-01, identify and measure from 100 Hz to 10 MHz, the

magnetic permeability and electrical conductivity of metals commonly used in hand-held weapons; produce a material database, and summarize the measurement techniques in a report.

Development of 2D Monolithic Microbolometer Imaging Arrays for Concealed Weapons Imaging

Presently, there are no monolithic array technologies that are being developed in the frequency range of 100 GHz to 1 THz, this range is the most appropriate for concealed weapons imaging because of the relatively short wavelength and the ability to penetrate clothing material. Monolithic detector arrays, using silicon integrated circuit processing technology, have the promise of being very inexpensive compared to present hybrid approaches (detector, mixer, local oscillator, etc., for each pixel). Furthermore, the present hybrid arrays must be scanned to provide sufficient areal coverage and resolution, and this scanning reduces system ruggedness and increases system cost. The low cost microbolometer arrays would simplify the design and lower the cost of 100 GHz to 1 THz concealed weapons imaging and detection systems, and this cost savings would benefit the law enforcement community.

MILESTONES: During FY-00, fabricate and characterize antenna-coupled detector arrays for concealed weapons imaging. Fabricate slot-ring hemispherical cavity bolometer and implement concept to wafer-scale array.

Identification and Characterization of Materials that Emulate the Low Frequency Electromagnetic (EM) Properties of the Human Body

Hand-held and walk-through metal detectors used for security applications may emit frequencies close to those used by PMEDs. The safety of persons with PMEDs is not an avoidable issue. Unfortunately, there is little information, other than anecdotal, about the interaction of PMEDs with HH and WT metal detectors. Furthermore, recent revisions of the NIJ standards for HH and WT metal detectors contain a body cavity concealment test. This test is based on using concealment by a person and although this test is representative of actual use, it is not reproducible or accurate. What is desired is a material that can mimic the electromagnetic properties of the human body over the frequency range of 80 Hz to 10 MHz so that the body cavity concealment test can be made reproducible and repeatable.

MILESTONES: During FY-00, develop and characterize a material that has nominally the same relevant electromagnetic characteristics as the human body and will allow evaluation and assessment of the interaction of PMEDs with the magnetic fields emitted by HH and WT metal detectors. This material can be used to model body cavity concealment of metal weapons and contraband items.

Liquid-Filled Camera for Enhancement of Shadow Detail

Video cameras used for surveillance and machine-vision applications often suffer from inadequate contrast capabilities, particularly in rendering details in shadows or dark regions. A camera technology that simulates the design of the eye promises to enable electronic cameras to render shadow detail that was previously impossible.

MILESTONES: By end of FY-02, build a 12 bit to 16 bit scientific grade charge coupled device (CCD) liquid-filled camera with housing and plumbing to provide continuous particulate filtration of the identified, low-viscosity, index-matching liquid-filler; test performance of internal aperture and computer model front lens design; increase dynamic range using thermoelectric cooling with mitigation of thermal gradient; reduce surface scattering at front lens element by wetting external surface of lens.

Unified Approach to Super-Resolution and Video Surveillance for Human and Vehicle Detection, Recognition and Identification

It is proposed that moving humans and cars could be detected, and then discriminated from other objects appearing in video sequences by using robust statistics and imposing spatial constraints (such as shape, size, etc.) and temporal constraints (such as rigid and non-rigid motion and shape deformation). Human faces could then be extracted using topological constraints (such as order and symmetry) and tested using a Bayesian hypothesis based on a set of face templates. Using multiframe data fusion, the extracted faces and car images could next be super-resolved. Human faces could be recognized in large databases using deformable shape and shading representations and composite matched filters. Cars could be recognized and identified using hierarchical features such as color, shape, logo and license plate number, and using contour-based shape representations, template matching, and optical character recognition.

MILESTONES: By end of FY-00, report on findings on improvements of human face recognition and vehicle identification in

video sequences, with the aim of increasing the efficiency of using surveillance systems in criminal justice applications.

NIJ Standard-0603.00, X-ray Systems for Bomb Disarmament

The latest Justice Department standard for x-ray systems for bomb disarmament was published during 1975. Changes in technology and changes in safety requirements imposed by other agencies have not since been documented. The laboratory selected for developing this standard, the Police Scientific Development Branch (PSDB) in the United Kingdom, has considerable expertise and experience in testing and deploying portable x-ray equipment. The PSDB has comprehensive laboratory facilities, including a large lead-lined laboratory and a variety of x-ray generators. The Explosive and Weapons Detection Group staff at PSDB are familiar with the general requirements of x-ray imaging systems and generators, as well as the associated health and safety issues.

MILESTONES: By the end of FY-00 the standard will be revised. Available commercial equipment will be tested for compliance to the standard and reported upon.

Emergency Warning Light Systems Evaluation

Emergency warning lights are the subject of Society of Automotive Engineers (SAE) Recommended Practice, SAE J595, January 1990. Flashing warning lights are intended to simulate human vision but are potentially detrimental if their brightness, number, and flashing characteristics dazzle approaching drivers. A case can be made that a large vehicle, such as a fire truck, should have a limited number of flashing lights in high positions, plus "clearance lights" that outline the vehicle shape, as well as traditional low-mounted taillights to provide a clue as to how far away the vehicle is. The whole back of the vehicle should not be so dazzling that the low-mounted taillights are lost in the clutter.

MILESTONES: To provide, within one year of the contract award, an extensive review of emergency vehicle warning lights, identify various emergency vehicle warning lights in current usage, and develop a catalog of emergency warning lights organized by type.

Emergency Vehicle Sirens Project

The objective of this project is to provide law enforcement agencies and other users of emergency vehicle sirens, such as emergency medical and fire services, with a single, improved, comprehensive document that includes test methods, performance criteria, and mounting and installation guidelines for sirens, which can be referenced in purchasing and other documents. It would be very useful if this siren document were cited by all public safety agencies, and used in a siren certification program that includes an independent test laboratory and laboratory certification agency. It is also the objective of this project to produce an NIJ siren guide that informs law enforcement agencies about the contents of documents that are currently recognized and used by the siren industry to specify siren tests, performance requirements, and mounting and installation guidelines.

MILESTONES: During FY-00, complete the siren guide and focus entirely on the SAE J1849 revision process. This process will require a significant amount of new written material as well as reorganization of SAE J1849. Some standards that may be relevant to the revision need to be identified and/or reviewed. It is likely that the process will also continue to include laboratory measurements to develop test procedures and performance requirements. The task members charged with preparing the first draft of SAE J1849 plans to meet twice a year in conjunction with the SAE Emergency Device Committee, and at other times as necessary.

Developing Evaluation Standards for Video and Still Face Recognition Systems

During FY-97 and FY-98, a digital video picture and still picture database was collected and methods for evaluating digital video-based face recognition systems were developed. These two activities laid the foundation for the Digital Video Face Recognition Evaluation Conference (DV-FREC). The project will run from FY-99 through FY-02, and is jointly funded by the Defense Advanced Research Projects Agency (DARPA) and NIJ. DV-FREC will independently evaluate the performance of digital video-based face recognition algorithms, and develop standardized test procedures.

Under this project, three DV-FREC evaluation conferences will be held. The product resulting from the first conference is expected to be ground truthing and scoring software, and an evaluation protocol. Conference

proceedings and a final report of the conference will be published. Two additional conferences will be held to encourage and measure progress in the future research goals that were identified in the first conference. Appropriate evaluation and data collection protocols will be designed to support the focus areas of the follow-on conferences.

A separate research effort, funded through OLES, involves continued collaboration with the University of Texas at Dallas (UTD). This project compares human and algorithm performance, and attempts to characterize how humans recognize faces.

MILESTONES: In FY-00, NIST will release the final version of the development database for the first DV-FREC, which will be held in April 2000. Follow-on conferences will be held in FY-01 and FY-02.

Auto Rank

The disposal and replacement of police patrol vehicles have major cost consequences for law enforcement budgets. Auto Rank is a sophisticated, statistical repair model developed at NIST and implemented in DOS software. The method uses data on the frequency of repairs for a vehicle class to estimate a generalized model of vehicle repairs based on the Weibull distribution, which is widely used for reliability analysis. Then, for each vehicle in the fleet, the model uses data on the particular vehicle's pattern of repairs to estimate expected repair costs for that vehicle over the coming period. Vehicle repair estimates can be grouped by repair category. The model then ranks all vehicles for disposal based on expected repair costs, operation and maintenance costs, and loss of resale value. The fleet manager then disposes of those vehicles with the highest predicted costs, resulting in a cost-effective strategy for vehicle disposal and replacement.

MILESTONES: By end of FY-00, complete all data collection on the failure/repair experience of several large fleets and prepare standardized data files for statistical analysis. Conduct statistical analysis on the failure/repair data to develop national estimates of repair frequencies, given the repair category, model year, and time of (or mileage at) the most recent failure/replacement (this analysis will rely on the Weibull distribution statistical model that NIST has already developed). Design and develop data files on repair frequencies to support dynamic computation of estimated future repair costs, even for small fleets, without sufficient data for on-line Weibull analysis. Develop software user interface, menu

structure, and data entry modules for fleet managers to record all their vehicles and repair histories. These data will be used to support estimation of future repair costs for each vehicle, taking into account its particular repair history.

AutoBid

A microcomputer system called AutoBid was developed to help police fleet managers select patrol vehicles best suited to their needs. The system is based on vehicle performance data for police patrol models published annually by the Michigan State Police and NIJ. AutoBid currently runs only on the DOS platform in character mode and has no graphical, windows-like features. An updated version of AutoBid with a modern, graphical interface is needed for all computer platforms.



Purchasing of police vehicles is aided by AutoBid.

MILESTONES: In FY-00, prepare the data files for the 2000 model year vehicles based on the latest Michigan State Police test results. These files will include the performance scores for ranking vehicles as well as the detailed hardware specifications of all tested vehicles. Post the new files on the NIJ web site and modify the HTML page for accessing the Java AutoBid software to permit users to select whether they want to analyze the 1999 or the 2000 model year data. Complete the AutoBid version that supports value based analysis based on comments and suggestions received from the Beta test. Add help screens to support the new features and design. Release the new software to the NIJ Internet site. Develop a brochure on AutoBid describing its features and how to access it on the NIJ Internet site.

Support of NHTSA Speed Enforcement/Measurement Program:

Across-the-road Doppler radar systems are being increasingly used by law enforcement authorities for measuring vehicle speeds on the nation's highways. These systems differ from older, down-the-road radar guns which are aligned with the direction of motion of the moving target vehicle in order to obtain an accurate reading of vehicle speed.



Law enforcement officer using a traditional down-the-road radar gun during speed enforcement operations.

The principle advantage of the across-the-road configuration, from a law enforcement viewpoint, is that the radar can readily differentiate between vehicles in dense traffic and can provide fast and automated identification of offenders using photographic techniques, while giving drivers essentially no advance warning of the radar's presence. The disadvantage of this technique is that the Doppler frequency shift from which the target speed is derived is no longer constant, but will vary with time as the cosine of the angle between the fixed direction of target motion and the fixed radar beam changes. This creates a very complex Doppler Spectrum with time, which is processed by the radar system using proprietary algorithms to yield a measurement of the vehicles speed. Consequently, it is essential that the measurement accuracy of these systems is guaranteed through frequent calibration using a reliable and traceable calibration standard.

MILESTONES: By end of FY-00 develop and build two improved prototype calibration devices intended to be used in compliance testing of automated across-the-road radar. One device is to be operated at the assigned police radar frequency centered at 24.1 GHz (K-band), the other centered at 34.7 GHz (Ka-band).

Accomplishments

- Submitted NIJ Standard-0601.01, Walk-through Metal Detectors for use in Weapon and Contraband Detection, to NIJ for publication. This standard establishes performance requirements and methods of test for active walk-through detectors for discovering metal weapons and metal contraband carried on a person and/or concealed by a non-metal object. This standard, resulting from the inadequacy of existing standards, provides the law enforcement and corrections community with

a mechanism for differentiating walk-through detectors for purposes of selecting better quality devices.

- *Submitted NIJ Standard-0602.01, Hand-held Detectors for use in Weapon and Contraband Detection, to NIJ for publication.* Responds to requests by the law enforcement and corrections community for a mechanism for differentiating the functionality and evaluating the performance of hand-held metal-weapon detectors. Existing standards do not specify measurement methods or test procedures to differentiate or evaluate hand-held metal-weapon detectors. This standard provides a means for selecting higher quality devices to improve the security of correctional institutions and public facilities while enhancing officer safety.

- *Submitted NIJ Standard-0227.00, Digital Intercept System for Integrated Services Digital Networks (ISDN), to NIJ for publication.* Specifies performance requirements and methods of test for intercept systems developed for exclusive use by federal, state and local law enforcement agencies to intercept voice, data and fax communications over ISDN telephone lines. This standard encourages performance improvement and assures a consistent presentation of the user interface to system operators.

- *Published NISTIR 5079, Dipole Moments of Weak Electrically Small Emitters from Transverse Electro-Magnetic (TEM)-cell Measurements, December 1998.* Addresses: (1) the development of a new method for characterizing weak, low frequency, emitters using measurements in TEM-cells, and (2) the measured emissions from commercial electrical timers of the type that could be used in bomb detonators. The new TEM-cell measurements method provides a simple, quantitative method for characterizing low frequency electric and magnetic field emissions. TEM-cells could be used for inspection of luggage and mail.

- *Submitted Report DOT HS 808-999, Speed Measuring Device Performance Specifications: Photo-Radar Module, to NHTSA for publication.* Developed under an interagency agreement with NHTSA, this standard sets systems performance requirements and verification procedures for automated across-the-road radar. Adoption of

the specifications by the IACP is expected to result in improved system accuracy and reliability, and in traffic administrators making better informed purchasing decisions. As automated across-the-road radar systems become more prevalent, the number and severity of automobile accidents on U.S. highways resulting from excessive speeds is expected to significantly diminish, as it has elsewhere in the world under similar conditions.

- *Submitted Report DOT HS 808-998, Speed Measuring Device Performance Specifications: Radar Module, to NHTSA for publication.* Traffic radar devices meeting or exceeding these performance specifications are internationally recognized by police, courts and the public as being reliable and accurate. Compliance testing is performed at independent university laboratories administered by the IACP under a grant from NHTSA. High speed and congestion are the leading causes of automobile crashes on urban interstates. Speed enforcement utilizing IACP-certified compliant radar units helps police and courts promote traffic safety.

- *Presented at the International Society for Optical Engineering (SPIE) Conference and published in Conference Proceeding 3575, the paper, "Specific NIST Projects in Support of the NIJ Concealed Weapon Detection and Imaging Program," November 1998.* Reports on work in progress in the area of concealed weapon detection for OLES by the Electricity Division. These projects, which were identified by the LECTAC of NIJ as important elements to combat domestic terrorism, specifically address:

1. revision of the standards for hand-held and walk-through metal detectors
2. preparation of a guide to non-eddy-current based detection and imaging methods (such as acoustic, passive millimeter-wave and terahertz wave, x-ray methods)
3. development of a prototype "stand-off" system for imaging and detecting weapons concealed on humans, and
4. development of terahertz (100 GHz to 10 THz) detector arrays

- *Presented at SPIE Conference and published in Conference Proceeding 3795, the*

paper, "Antenna-coupled Niobium Bolometers for mm-Wave Imaging Arrays," July 1999.

Fabricated and measured the electrical properties of mm-wave imaging array pixels consisting of half-wave dipole antennas coupled to niobium microbolometer detectors on an electrically thick silicon substrate. To improve the signal-to-noise ratio, the uncooled detectors are operated in a pulsed illumination and gated integration architecture. These arrays are being developed to demonstrate the feasibility of an active mm-wave concealed weapon imaging system. Most clothing and many common building materials are transmissive to electromagnetic radiation at millimeter wavelengths.

- *Siren Testing: Round-Robin Testing Shows Good Agreement.* Showed the feasibility and reliability of doing acoustic testing on siren loudspeakers separately from their electronic signal amplifiers. In a project for OLES, the Acoustics, Mass and Vibration Group, in cooperation with a committee of the SAE, did an intercomparison of siren tests using NIST's large anechoic chamber, and two industrial laboratories. The result was close agreement, on the order of 1 dB, for spectra measured by the laboratories. This is encouraging to the SAE committee, which hopes to revise a recommended practice, permitting siren loudspeakers and siren amplifiers to be tested separately.

- *Siren Amplifier Testing: Instrument Comparison Shows Good Agreement.* Tested ten siren amplifiers from six manufacturers, using two dissimilar instruments: a one-third octave band real-time analyzer and a fast Fourier transform (FFT)-based dynamic signal analyzer to characterize their electrical output. The SAE committee responsible for siren standards is developing new procedures in which siren speakers and siren electrical components can be tested separately. Currently, the plan is to define standard signals that can be used to test siren loudspeakers, and develop test procedures that compare the amplifier outputs with these standard signals. (A siren amplifier, by definition, incorporates a signal generator.)

- *Police Car Purchasing Aid is now a Click Away.* Re-wrote our old DOS-based police car selection program AUTOBID into a Java program. One version can be run by itself, while the other so-called applet version is only

a couple clicks away for users viewing the OLES web page:

<http://www.eeel.nist.gov/oles>. The user describes numerically what features are most important to his or her department, and the program ranks available police cars. This project was done by NIST's Office of Applied Economics, BFRL, and sponsored by OLES.

Publications

NIJ Guide 500-99, "Guide to Test Methods, Performance Requirements, and Installation Practices for Electronic Sirens Used on Law Enforcement Vehicles," accepted for publication August 1999.

NIST Technical Note 1398, "Portable Calibrator for Across-the-Road Radar Systems," May 1998.

NIST IR 5079, "Dipole Moments of Weak, Electrically Small Emitters from TEM-Cell Measurements," December 1998.

NIST IR 5787, AutoBid 2.0, "The Microcomputer System for Police Patrol Vehicle Selection," Revised June 1998.

NIST GCR 99-771, "State of Oregon Criminal Justice Information System: Mug Shot Imaging Project," approved for publication September 1999.

Proceedings of SPIE Reprint, "Enforcement and Security Technologies," November 1998.

"Specific NIST Projects in Support of Concealed Weapon Detection and Imaging Program," SPIE Volume 3575, Law Enforcement and Securities Technology Conference (November 1998), Boston, MA (N. Paulter).

"Antenna-Coupled Niobium Bolometers for mm-Wave Imaging Arrays," SPIE Volume 3795, Optical Science, Engineering and Instrumentation Conference (July 1999), Denver, CO. (S. Nolen, et. al.).

NIJ Standard-0601.00, "Walk-Through Metal Detectors for Use in Weapon and Contraband Detection," in print.

NIJ Standard-0602.01, "Hand-Held Metal Detectors for Use in Weapon and Contraband Detection," in print.

NHTSA Technical Report DOT HS 808-998, "Speed Measuring Device Performance Specifications: Radar Module," November 1999.

NHTSA Technical Report DOT HS 808-999, "Speed Measuring Device Performance Specifications: Photoradar Module," November 1999.

NIJ Standard-0227.00, "Digital Intercept System for Integrated Services Digital Networks," in print.

Chemical Systems and Materials

Technical Contact:

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Staff-Years:

7.8 professionals

Funding Sources:

100% Other Government Agencies

Project Champions:

- Chemical Science and Technology Laboratory (CSTL), Analytical Chemistry Division
- Building and Fire Research Laboratory (BFRL), Office of Applied Economics
- EEEL, Electricity Division
- U.S. Army Research Laboratory (ARL), Aberdeen, MD
- U.S. Department of Justice
 - National Domestic Preparedness Office (NDPO)
 - Office of State and Local Domestic Preparedness Support (OSLDPS)
 - Federal Bureau of Investigation (FBI)
- University of Utah, Center for Human Toxicology (CHT), Salt Lake City, UT

Project Goals

To manage programs and direct research and development efforts in the areas of polymers, chemical systems and materials, including, but not limited to, protective clothing and equipment, drugs of abuse, less-than-lethal technologies, and weapons of mass destruction. To develop quality assurance programs and performance standards, guidelines, and reports in support of the goals and priorities of both NIST and the outside agency sponsors.



A typical protective mask for first responders, law enforcement officers, corrections officers, and EMS providers.

Technical Strategy

Development of a NIST Standard Reference Material "Additives in Gunpowder"

Most handgun and improvised explosives (pipe bomb) crimes involve the use of smokeless gunpowder. Forensic investigators are increasingly measuring the composition of the gunpowder and its recovered residues to help identify the source of the powder as part of criminal investigations. However, there currently are no smokeless powder samples of known composition for use in analytical method evaluation and measurement proficiency testing. To assure the quality of gunpowder measurements, OLES is funding work through the Analytical Chemistry Division of the Chemical Sciences and Technology Laboratory (CSTL) at NIST to develop a Standard Reference Material (SRM),

"Additives in Smokeless Gunpowder," that will aid forensic investigators in testing and validating their analytical measurement techniques.

Smokeless gunpowder is a mixture of propellants, such as nitrocellulose and nitroglycerin (NG), as well as stabilizers such as diphenylamine (DPA) and ethyl centralite (EC). The proposed SRM will consist of two types of gunpowder, ball and extruded powders, with certified concentrations of NG, DPA, and EC. The certification of chemical composition SRMs typically requires the use of two or more chemically independent analytical techniques to provide measurements, which if in agreement, are used to assign certified values to the material.

MILESTONES: During FY00, the development of the analytical methods for certification will be completed and preliminary compositional measurements on the two prototypes will be made to assess the agreement of the independent techniques. The independent techniques will be applied to the detailed certification measurements of the candidate gunpowder materials for the SRM. Rigorous statistical evaluation of the data will permit determination of the certified values for the three additives.

Computer Database of Energetic Materials Spectra

Currently, forensic identification of energetic materials (explosives and propellant formulations) is accomplished in a variety of ways. Typical test methods include gas chromatography (GC), liquid chromatography (LC), mass spectrometry (MS), infrared reflection (IR), and absorption spectroscopy, and the tandem applications of these techniques (e.g., GC-FTIR-MS, LC-MS, etc.). Each of these methods has its advantages and disadvantages. Liquid chromatography usually requires significant sample preparation and yields limited information unless employed in tandem with other techniques. Mass spectrometry and gas chromatography require some portion of the sample in the gas phase, often requiring sample heating. For many explosive materials this is difficult to achieve without decomposition.

Infrared spectroscopy can be used to measure the vibrational spectrum of nearly all energetic materials. Raman spectroscopy is also an excellent technique for identification and characterization of energetic materials and propellant formulations. Each of these

techniques can yield excellent results for many samples. This project is aimed at expanding the current Raman spectral database to include spectra of energetic materials. This expansion will include mass spectra and infrared absorption spectra of energetic materials, and will use the framework currently employed for the Raman spectral database (GRAMS32). The current Raman spectral database (Version 1.0) is available to all law enforcement agencies as a forensic tool for identification and characterization of energetic materials. As with the current version of the database, the expanded database can be upgraded, allowing new spectra to be entered as needed. The inclusion of mass spectra and infrared spectra of energetic materials will make the database even more accessible to other investigators. The Army Research Laboratory (ARL) at Aberdeen, Maryland, which has extensive experience measuring mass spectra and infrared spectra of energetic materials by several techniques, including GC-MS, LC-MS, solid probe MS, infrared reflectance spectroscopy, photoacoustic spectroscopy, and normal transmission spectroscopy, will do the work.

MILESTONES: *The first version of the expanded spectral database is scheduled to be delivered to OLES by June 2000. ARL will supply an expanded database of spectra to include Raman spectra, mass spectra, and infrared absorption spectra of neat energetic materials, propellant ingredients, and propellant and explosive formulations. The expanded database will be contained within the framework of commercial spectral manipulation software. The database will be available to all federal and state agencies free of charge.*

Support of Domestic Preparedness Programs

NIJ has requested that OLES develop guidelines, test protocols, and standards for chemical and biological (CB) warfare detectors, personal protective equipment, and decontamination equipment for first responders. This effort is divided into two phases.

Phase 1: Develop guidelines for chemical and biological warfare (CBW) agent detection equipment, personal protective equipment (PPE), first aid kits, decontamination equipment, and command and control equipment for use by emergency first responders at the state and local level in the event of a CB terrorist incident.

An Interagency Agreement (IA) between OLES and the Department of Defense (DoD) Defense Technical Information Center (DTIC) was signed in early 1999. The Chemical and Biological Defense Information Analysis Center (CBIAC), through its support of the DoD Domestic Preparedness (DP) Program under CBIAC Tasks 240 and 252, has acquired extensive CBW equipment literature for application to this effort and has the requisite technical experience and expertise to effectively accomplish this effort. This IA sets out the conditions under which this project of joint interest to OLES and DoD will be conducted.



A chemical/biological protective suit

The purpose of this agreement is to authorize Battelle Institute to conduct information collection and analysis activities through DTIC to provide information of joint interest to OLES and DoD, which will contribute to the needs of the U.S. Domestic Preparedness Program. This work is necessary to provide access to information available at CBIAC to accelerate the preparation of Chemical and Biological equipment guidelines for implementation under the U.S. Domestic Preparedness Program.

This task, which officially started in May 1999, is estimated to take 16 months, except

for the guideline for the command and control equipment (CCE). The CCE has to be developed as a separate effort and is expected to take more than 2 years because of lack of data in this area at this time.

Phase 2: Working with other federal agencies such as National Institute of Occupational Safety and Health (NIOSH), the Occupational Safety and Health Administration (OSHA), the National Domestic Preparedness Office (NDPO), and the National Fire Protection Association (NFPA), develop standards that all stakeholders can use for test and selection of CBW personnel protection equipment, and perform testing to determine characteristics of the instruments and their capabilities for detecting CBW agents under various conditions and situations.

This effort is estimated to be a 3 year to 4 year effort. The various tasks that will be performed include review of existing standards, development of key CBW equipment requirements (i.e. what are considered to be safe levels), modification and/or development of test methods as necessary, validation of test method acceptability, and preparation of final standards. These standards will address performance, testing, quality, conditions and limitations of use, and certification requirements and/or procedures.

MILESTONES: Complete chemical agent detection equipment guide by January 2000. Complete biological agent detection equipment guide by March 2000. Complete CBW personal protection equipment guide by May 2000. Complete decontamination equipment guide by May 2000. By June 2000, develop a standardized guideline for the evaluation and purchase of CB equipment for use by national emergency responders at the state and local level in the event of a CB terrorist incident.

Less-than-Lethal Technologies: Examination of Pepper Spray Canisters

For the entire period of the NIJ program and those of its predecessors, the issue of capturing alleged perpetrators without resorting to deadly force has been pursued. A court case, Tennessee vs. Garner, revealed an urgent need to examine non-deadly force methods for apprehending and subduing violent offenders. The OLES program in this area is in support of NIJ's Less-than-Lethal objectives.

Various chemicals have been employed as incapacitating agents. CS and CN tear gases

have been used by police and military for riot control for many years. However, they are not as suitable for use against individuals as oleoresin capsicum (OC). Recent findings have shown that OC is an effective incapacitant, reducing assaults against officers, reducing injuries to officers and suspects, and reducing the number of complaints of excessive police force.

Administration of OC has been found to result in effective incapacitation 85 % to 90 % of the time. The reasons for the 10 % to 15 % failure rate include low concentration of OC in the canister, poor delivery because of low pressure, bad aim, variability of subject responses, or a combination of these factors.

Through previous work, NIST has developed some expertise in sampling and analyzing the contents of pepper spray canisters, making quantitative measurements of the internal pressure and the concentrations of capsaicinoid compounds present in the spray. The examination of the contents of the used canisters and the correlation of the analytically measured properties of the contents with the known rates of success or failure of the application is expected to shed light on the reasons for failures. Furthermore, these studies may suggest product improvements as well as become the basis for minimum voluntary labeling standards that are based on active ingredient concentration rather than the amount of pepper in the spray.

MILESTONES: In FY-00, a contract will be issued to continue characterizing pepper spray canisters. Additionally, one or two local police jurisdictions that routinely use OC spray and have a good training program for their officers on how to properly use this product, will be asked to participate in this project.

Less-than-Lethal Technologies: Human and Animal Dose Response, Toxicokinetic and Potency Assessment of Pepper Spray Products Following Topical and Aerosolized Exposure

Oleoresin Capsicum (OC), or pepper spray, products have now gained wide acceptance in the law enforcement community as a less-than-lethal (LTL) weapon. When sprayed into the face of an assailant, suspect or inmate, OC causes a reversible physiological reaction. It may cause lacrimation, temporary blindness, a burning sensation (pain) on the exposed skin, coughing, gagging, shortness of breath,

decreased muscle coordination, confusion, and disorientation. These effects are immediate, subside within 30 to 45 minutes, and rarely produce any enduring side effects. Generally, law enforcement agencies have reported success when using OC weapons. The problem, however, is the wide variability in concentrations of capsaicins, pungency, and pain thresholds of the commercially sold OC sprays.

The objectives of this 3-year project are to evaluate the efficacy and potential toxicity of pepper spray products as a function of the qualitative and quantitative content of capsaicins. Specific tasks under this project are to:

- Chemically characterize a series of pepper spray (OC) products as a method of determining, and ultimately predicting, product potency;
- Determine response and potency to human skin of products and the individual capsaicins identified in the products;
- Investigate the toxicological effects of inhalation of these products;
- Determine the extent of absorption and the distribution of these analogs following dermal and nasal exposure. Nasal exposure will be to drug-free and drug-treated rats.

With these data we expect to be able to do the following:

- Predict product potency by chemical analysis, dermal response or a combination of the two methods;
- Determine the relative potency of the individual capsaicin analogs;
- Determine and quantify the effects of the products and the individual capsaicins when applied dermally;
- Develop sensitive and specific analytical methods that can be used to identify and quantify capsaicin analogs in pepper spray products and in biological samples;
- Determine the extent of dermal absorption of the major capsaicin analogs;
- Determine toxicity and the extent of nasal absorption of the major capsaicin analogs following aerosolized exposure and determine if stimulant drug use affects toxicity or absorption.

MILESTONES: The goals during the first year of this effort (FY-00) are to issue a grant through which OC sprays will be chemically characterized, and their

potency, effectiveness, and toxicity evaluated.

Minimizing Compliance Costs of the Life Safety Code for Correctional Facilities

The Fire Safety Evaluation System (FSSES) for Detention and Correctional Facilities (Chapter 4 of the NFPA 101A Guide to Alternative Approaches to Life Safety) offers the managers and fire safety engineers of such facilities many alternatives equivalent to prescriptive code compliance. This flexibility makes possible major cost savings when achieving compliance with the Life Safety Code. Because so many acceptable solutions are available, the most cost-effective solutions cannot be found by simple trial and error. What is needed is a systematic procedure for finding a practical set of low-cost, safety-equivalent solutions from which the facility manager can choose. The NIST Office of Applied Economics has successfully developed a similar procedure and supporting software for Health Care Occupancies. The Public Health Service has applied this software to 86 military hospitals and identified code-compliant solutions with cost savings of over 40 % (about \$2,200 per bed) compared with the prescriptive solution.

MILESTONES: Develop the life-cycle cost model for design alternatives. Obtain all cost data and develop the algorithms necessary to estimate the life-cycle cost of qualifying for each of the 56 states of the fire safety parameter table of NFPA 101A. Complete the cost minimization model and supporting algorithms capable of systematically evaluating the costs of all safety-equivalent alternatives to identify quickly the least-cost alternative for any correctional facility. Design and develop software for easy user specification of the current safety conditions for each of the 13 fire safety parameters and for the quantities of each construction retrofit to be considered for evaluation by the cost minimization model and algorithms. Design and develop software modules to apply the cost minimization model and supporting algorithms to identify the least-cost alternative for any correctional facility.

Accomplishments

- *NIJ Guide 100-99, "Guide for Portable Explosives Detection Systems," approved for publication.* Completed a survey and evaluation of commercial, portable explosives detection systems for law enforcement applications. The project was carried out in collaboration with Sandia National Laboratories. Once the Guide is published by

NIJ, it will be available to public safety agencies to help them make procurement decisions in purchasing equipment as part of the domestic preparedness program.

Publications

NIJ Guide 100-99, "Guide for the Selection of Commercial Explosives Detection Systems for Law Enforcement Applications," approved for publication April 1999.

NIJ Report 100-99, "Evaluation Methodology for the Selection of Commercial Explosives Detection Systems for Law Enforcement Applications," approved for publication April 1999.

Forensic Sciences

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Funding Sources:

100% Other Government Agencies

Project Champions:

- Building and Fire Research Laboratory (BFRL), Fire Safety Engineering Division
- Chemical Science and Technology Laboratory (CSTL):
 - Biotechnology Division
 - Analytical Chemistry Division
- Department of Defense (DoD), Computer Forensics Laboratory
- Federal Bureau of Investigation (FBI)
- Information Technology Laboratory (ITL), Software Diagnostics and Conformance Testing Division
- Institute for Social Analysis (ISA), Alexandria, VA
- Manufacturing Engineering Laboratory (MEL), Precision Engineering Division
- Materials Sciences and Engineering Laboratory (MSEL), Ceramics Division
- National Cybercrime Training Partnership (NCTP), under the Computer Crimes and Intellectual Property Section of DOJ
- Royal Canadian Mounted Police (RMCP), Forensic Laboratory, Ottawa, Canada
- TASC, Inc., Arlington, VA
- University of Utah, Center for Human Toxicology (CHT), Salt Lake City, UT
- U.S. Secret Service (USSS), Washington, DC

Project Goals

To manage forensic science programs and direct research efforts to develop performance standards, guidelines, and reports to advance the technologies associated with the forensic science field. To provide innovative and validated test methods that will successfully undergo the scrutiny of our adversarial justice system.

Technical Strategy

Development of National Electronic Crime Software Library

The FBI Computer Analysis Response Team (CART) Unit has established a baseline database for the Known File Filter utility employing commercial off-the-shelf (COTS) software packages. The information in the database constitutes a standard reference material (SRM) for verifying the authenticity of software files. The metric for the SRM is hashing algorithms. Using several hashing algorithms (e.g., SHA, MD4, and MD5), a file signature for each of the COTS files is created. An automated database population utility has also been developed to enable the population efforts of these software packages. Along with this database, a National Software Library of obtained COTS products (products that form the basis of the database) has been established. A distribution mechanism for the database to Automated Computer Examination System (ACES) users is being developed.

Under this project, OLES will build upon the FBI CART Unit's baseline database for the Known File Filter utility, maintain current entries, and update and append the database with new entries for additional software on the PC platform as well as additional computing platforms. Both the creation of file signatures from COTS software using hashing algorithms and the distribution of this standard reference material to ACES users will be performed. A library of COTS software will be maintained for COTS software that is obtained.

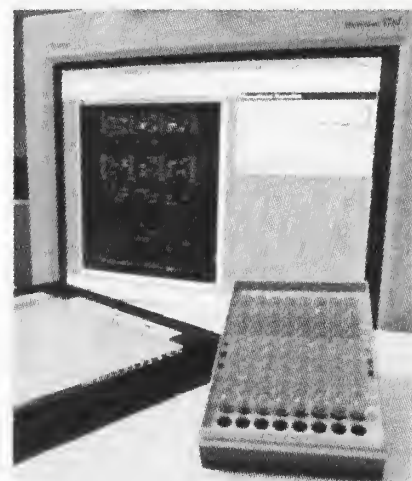
Additionally, utilities that enhance the operational usefulness of the database will be developed. Comparison and validation tests will be performed to verify that the Microsoft Access database properly emulates the CART Unit's functionality.

The ability to create the standard reference material will be demonstrated: e.g., information from the database will be extracted onto a CD for distribution and verified that it correctly represents the database information.

MILESTONES: In FY-00, an Access database that reproduces the CART Unit's baseline database contents and functionality will be prepared. A software library will be established and maintained. Demonstrate, with a COTS package, the ability to generate the file signature, populate the database, and extract the information from the database. Establish a Software Library to house obtained software packages, including a method to catalog and keep track of the software and its versions.

Establishment of a Computer Forensic Tool Verification Capability at NIST/Validation of Computer Software Tools

There is a critical need in the law enforcement community to have validated computer forensic procedures and validated computer forensic tools. The DoD Computer Forensics Laboratory (DCFL) has begun testing software, but not on a continuous basis, nor with an established, quality assurance set of procedures or processes. Although informal coordination with other law enforcement agencies has been done in regard to software testing, a more coordinated effort is needed.



Results from electrophoresis analysis of DNA sample.

Under this project, requirements, procedures, processes, documentation, etc. that will be contained in the test plans and criteria will be defined. Test plans (policies and procedures) and forensic tool testing criteria will be

developed. Additionally, a testing program will be established to test the forensic software on different platforms and validate the test plans and criteria. All necessary hardware, networking, and software required to perform testing will be obtained.

MILESTONES: *In FY-00, a preliminary draft of the test plan will be developed. An interim test laboratory at NIST will be established, and testing of software will begin.*

Development of Best Practices for Electronic-Crime Investigation

Criminal justice professionals would benefit from advanced training related to investigating crimes that involved electronic media. A comprehensive training program to include introductory through the most advanced levels needs to be developed. This training can be implemented in a sequential manner, beginning with introductory level courses and then incrementally providing higher level courses.

OLES/NIST will assist NIJ in developing, preparing, and disseminating best practices guidelines for conducting electronic-crime investigations. In developing the best practices, OLES will enlist the support of expert practitioners from all levels of the criminal justice community, including crime lab analysts, field investigators, and litigation experts. A series of pocket-sized best practices booklets will be produced that, collectively, cover topical areas that range from management awareness to courtroom presentations. Tentative topic areas of each booklet of the series are as follows:

- Managing Technology in Law Enforcement;
- Crime Scene Guidelines: Identification, Collection, Preservation, Transfer, and Storage;
- Analysis of Computer Evidence;
- Investigative Use of Technology;
- Investigating Technology Crimes;
- How to Set Up a Digital Evidence Laboratory; and
- Courtroom Presentations of Digital Evidence.

A planning panel will be formed for each best practices booklet in the series. Each panel will consist of approximately 12 to 18 criminal justice experts who will convene to define the scope and content of the booklet, and to

prepare a draft outline for the booklet. The planning panels will also assist OLES in identifying appropriate criminal justice and electronic-crime experts that will serve on a technical working group (TWG) to be formed for each of the individual best practices booklets. TWGs will consist of about 50 to 70 expert persons. Each TWG will develop a first draft booklet and edit each successive draft.

MILESTONES: *In FY-00, OLES will begin to conduct Planning Panel discussions to develop and draft guideline booklets.*

Burn Pattern Recognition Program

Due to the increasing difficulty in determining the cause and origin of fires with currently available technologies, the crime of arson is difficult to investigate and successfully prosecute. Fires present in structures will interact with parts of the enclosure, changing the burning behavior of the fire. This interaction may also leave burn patterns, signs of the fire's presence and development, for interpretation by fire investigators.

Previous work has shown that some traditionally used indicators, or burn patterns, may erroneously imply that flammable liquid accelerants were used in a fire. The previous phase of this study provided insights into the use of indicators upon which fire investigators typically base their conclusions concerning the origin and development of fires. The conclusions from these experiments are contained in NIJ Report 601-97, "Full Scale Room Burn Pattern Study." One conclusion is that the formation of burn patterns are highly dependent on ventilation conditions, and the study would benefit from tightly controlled experimental conditions.

In continuing support of this program, the effect of radiant heat flux from hot gas layers on flammable-liquid-spill burn patterns in structures will be investigated.

MILESTONES: *In FY-00, instrumented, full-scale experiments will be conducted to investigate the effects of radiant heat flux on floor burn patterns from flammable liquid spill fires.*

Establishment of NIST/NIJ Forensic Analysis Fellowship

Forensic science requires an increasing amount of technical sophistication. However, support for the post-baccalaureate education of forensic scientists is woefully inadequate. In the U.S., there are currently only seven

universities offering Master's degree programs and only one recently established Forensic Science Ph.D. program. Most forensic practitioners with advanced degrees have crossed-over from allied fields such as the sciences or engineering, and have achieved their knowledge of forensic science via "on-the-job" training.

The lack of support for graduate students pursuing a degree in forensic science is a serious impediment to expanding advanced degree program enrollment in forensic sciences. Traditional funding sources, such as the National Science Foundation, generally sponsor more basic scientific research at Ph.D. and post-doctoral levels. This leaves forensic science faculty and students little opportunity for research funding.

In its role as the primary national resource for criminology and jurisprudence, the NIJ is the most appropriate locus for an effort to improve the quality of forensic scientists via advanced educational opportunity. Of particular importance is the ongoing NIJ program to assess and meet the advanced technology needs of the forensic community. Through this activity, NIJ is uniquely suited to prioritizing the research advances required to meet national needs. OLES/NIST also brings a unique and advantageous perspective to the effort for improving the quality of forensic measurements. As the needs for technical accuracy and quality of forensic measurements continue to advance, NIST is uniquely suited to help to meet those needs. Our well recognized technical competence will be combined with our neutral status to build a powerful and influential effort to advance forensic measurement research.

Initially, this program will fund a summer fellowship opportunity for post-baccalaureate research in the NIST laboratory. In FY-99, an intern from the Master of Forensic Sciences program of the George Washington University was supported under this project in our NIST Analytical Chemistry Division to advance the detection and measurement of the organic compounds in handgun and explosives residues. This summer project addressed the persistence of organic gunshot residue composition with a change in ammunition.

In future years, we envision this program growing to support a limited number of student interns at NIST or other federal

forensic agencies, or student researchers at universities with forensic science degree programs. Priorities for research support will follow the national forensic science needs determined by NIJ. Proposals from all major universities with forensic science degree programs will be solicited. Evaluation of proposals will be based on quality, alignment with NIJ forensic research priorities, and by student qualification as determined by NIST/OLES staff and will include at least one independent review.

MILESTONES: *We propose a partnership between NIJ and NIST/OLES to establish a NIST/NIJ Forensic Analysis Fellowship as one mechanism to advance the skills of the next generation of forensic scientists.*

Evaluation of Saliva as an Alternate Drug Testing Specimen

Recent studies have shown that nearly two out of three of all suspects arrested for crimes admit to drug use and one out of three admit to use during the crime. Likewise, nearly two out of three of drivers involved in fatal highway accidents test positive for drugs or alcohol. As a result, the American public has become considerably more sensitized to drug and alcohol abuse and has emphasized the need to evaluate the effects of drugs and alcohol on public safety and the environment. Therefore, the ability to rapidly determine drug concentrations is needed by the law enforcement community to support criminal and civil investigations.

The current methodology for analysis of drugs involves the use of blood, plasma, or urine as samples. However, obtaining these samples is either invasive, or they can be adulterated. Saliva, on the other hand, can be obtained non-intrusively, allows protection of privacy, reduces the possibility of adulteration, and has the potential for estimating the actual circulating concentrations of drugs. In addition, saliva is a filtrate of blood and is therefore far less complex and more easily prepared for analysis. Little is known about the mechanisms with which drugs are actually transferred from the blood into saliva. Therefore, an understanding of these mechanisms must be obtained to estimate the extent and rate of transport of the drugs into the saliva.

Saliva specimens from subjects will be collected by "spitting" into inert polyethylene tubes without stimulating saliva production.

It is known that drug disposition into saliva is affected by pH and collection techniques. Therefore, four additional common collection techniques/devices will be evaluated in the controlled clinical studies. These include: (1) citric acid (hard candy) used to stimulate saliva production; and (2) non-acid stimulation of saliva production (chewing on Teflon, rubberband, etc.). Two additional commercial collection devices will be chosen for evaluation.

To be useful as a testing specimen, a rapid drug screening method is needed for the matrix. This is a potential problem with saliva since the parent drug is often detected, whereas commercial immunoassay tests generally target urinary drug metabolites.

In order to evaluate the need for hydrolysis of codeine and morphine conjugates to improving the detection in saliva samples, glucuronide metabolites of codeine and morphine in saliva will be analyzed. A LC/MS/MS method for determining morphine and morphine glucuronide metabolites using solid phase extraction has already been validated and can easily be adapted for the detection of codeine and codeine glucuronide.

MILESTONES: Complete the analysis of all saliva, hair, plasma, and urine samples collected in FY-99. Special emphasis will be placed on the relationships between dose and specimen concentration.

Use of Enantiomeric Composition to Study Incorporation of Drugs into Hair

The analysis of hair for drugs of abuse can provide a number of advantages when compared to the analysis of urine or other biological fluids. Hair provides a view of drug use over a greater period of time and is more difficult to evade than urinalysis. Several issues have slowed the acceptance of hair analysis, including a lack of understanding of drug incorporation mechanisms, a lack of reference materials, and the possibility of false positives arising from passive (environmental) exposure.

Amphetamine and methamphetamine are commonly abused stimulants that can be prepared through a variety of synthetic pathways. Both compounds have been detected in hair samples of drug users. Because amphetamine and methamphetamine are chiral molecules, they can exist as pairs of

enantiomers. The (R)-enantiomer of methamphetamine is found in legitimate pharmaceutical products, but clandestine synthesis often produces racemic amphetamine and methamphetamine. Metabolism of methamphetamine produces amphetamine, and stereoselective metabolism of both compounds has been reported. Therefore, proof of illicit use of these stimulants requires an examination of enantiomeric composition of the compound of interest. Current analytical methods for the measurement of enantiomers of these stimulants typically involve derivatization with enantiomerically pure derivatizing agents to form diastereomers that are separated by gas chromatography (GC). However, most chiral derivatizing agents are not enantiomerically pure, and impure reagents may perturb the initial enantiomeric composition of the sample, leading to erroneous or misleading results. Analytical methodology that does not require chiral derivatizing agents would likely improve the reliability of enantiomeric measurements. In addition the availability of standards of known enantiomeric composition of amphetamine/methamphetamine would aid validation of analytical techniques for measurement of amphetamine and methamphetamine in hair samples.

In this project, an analytical methodology for the determination of enantiomeric ratios of amphetamine and methamphetamine in hair will be developed. Standard reference materials containing these compounds will be certified.

MILESTONES: Develop the methodology for the separation of amphetamine and methamphetamine enantiomers by gas and/or liquid chromatography.

Innovative Sweat-Based Drug Testing Technology Development

The current methodology for analysis of drugs involves the use of blood, plasma, or urine as samples. However, obtaining these samples is either invasive, or they can be adulterated. In addition, their matrices are relatively complex thus requiring more intensive and time-consuming sample preparation and/or determination. Sweat, on the other hand, can be obtained non-intrusively, allows protection of privacy, reduces the possibility of adulteration, and has the potential for estimating the actual circulating concentration of drugs. In addition, sweat is a filtrate of

blood and is therefore far less complex and more easily prepared for analysis. This proposal focuses on the development of sweat-based drug testing techniques.

The objectives of the research project are to:

- test the current commercially available equipment for use as sweat collection devices for adult subjects and modify them as needed to improve both performance and reliability of the devices;
- adapt assay test kits for use in testing liquid perspiration; and
- assess the validity and utility of the liquid perspiration collection technique as a method for testing criminal populations.

The research will be performed over a period of three years. During the first year, a thorough literature review will be conducted specially targeting non-invasive techniques for collecting and testing sweat. Experts in the field will be contacted and consulted to select the most promising devices as well as to identify laboratory-based screening methods. Available liquid-perspiration collection devices will be examined and reviewed. The investigators will work closely with manufacturers of such devices to improve and modify as necessary for use in criminal justice populations. Pilot tests of selected devices will be conducted. The results of this first stage will be analyzed and documented in an interim report.

MILESTONES: *In FY-00, liquid perspiration devices will be tested and modified; and immunoassay screening methods will be evaluated.*

Update of NBS Special Publication 480-17 – Auto Headlight Glass Visible Features of Forensic Utility

This project addresses the update of the NBS Special Publication 480-17, "Glass Auto Headlights for Forensic Utility", which was issued in February 1978. This publication is presently of very limited use in forensic studies because it covers only headlights of the sealed beam type which were installed in U.S. passenger vehicles made between the years 1962 and 1974.

The objective of this project is to develop a database of headlight characteristics for identifying headlights installed in the "Top-Selling Models" of current production passenger vehicles sold in the U.S. The

database is intended to aid law enforcement officials in forensic investigations aimed at determining vehicle identification from headlight fragments left at the scene of an accident or hit-and-run crime situations.

The headlights manufactured today are completely different from those manufactured prior to 1978, when SP 480-17 was issued. The present market and application of headlights in vehicles is larger and much more complex. There are also additional complexities involving materials and design. Today's headlights are made of glass, plastic, or glass-plastic hybrids, for application in passenger cars and trucks [sport utility vehicles (SUVs), minivans, vans, and light trucks]. The headlights' purchasing and referencing system is very intricate. A significant fraction of headlights is made offshore.

The first priority is to collect and evaluate information for the development of a database on automotive headlights for forensic use. The database will include the identification and visual characteristics of headlights, such as patterns and markings of sealed beam and plastic headlights installed in "Year 2000 Top-Selling Models" sold in the US. Work planned for FY-00 includes the following:

- Continue to develop essential key contacts and relations through telephone calls, visits, presentations and meetings with: 1) automakers and headlight suppliers to obtain parts, data, and other information on the identifying characteristics of headlights installed in Year-2000 "top-selling models;" 2) SAE International Committee on Headlights to promote and develop collaborations with industry on the gathering of headlight data for forensic analysis; and 3) law enforcement entities, forensic labs, and associations to learn more about their needs.
- Identify database structure, design, and applicable software.
- Establish technical collaborations to photograph headlight features and to carry out characterization studies on selective properties as applicable (e.g., refractive index, density, spectroscopic or elemental analysis).

MILESTONES: *Collect and evaluate data for the development of a database of automobile headlights. Identify database structure, design, and applicable software. Establish technical collaborations, to*

*perform photography of headlamps features
and to carry out characterization studies.*

Research in Deoxyribonucleic acid (DNA) Identification Methods and Standards

The Biotechnology Division of the Chemical Science and Technology Laboratory has been the lead organization for DNA research for NIJ and NIST. So far, the Division has developed SRM 2390 for use in calibrating DNA tests based on the restriction fragment length polymorphism (RFLP) method, and SRM 2391 for tests based on the polymerase chain reaction (PCR) method. These SRMs have contributed immeasurably to the current accuracy of DNA measurements and the ability of laboratories to successfully defend the measurements in court.

A major objective of this project is to provide fundamental research and development on all aspects of current DNA forensic testing with the goal of providing NIST traceability to all U.S. crime laboratory measurements on DNA for human identification.

The focus areas are, briefly:

1. Quantification of DNA at low levels is a major problem in PCR-based tests. NIST has developed several scenarios to test federal, state, and local crime laboratories for their ability to accurately quantify nanogram to sub-nanogram levels of DNA.
2. Identifying mixed stains with multiplexed Short Tandem Repeat (STR) kits presents a formidable problem. An interlaboratory exercise will help pinpoint specific problem areas.
3. Many laboratories are switching to room-temperature preservation methods by use of specially treated paper as their mode of preserving DNA from convicted offenders. Published validation of this technology has left out some critical studies on variability of multiplexed samples. These studies have already been started at NIST.
4. Identification of individuals through hair testing needs additional research to address heteroplasmy quantification issues. Strategies to address this problem have been outlined and are ready to be implemented. Site-directed mutagenesis will be used to modify a single base in a long mitochondrial sequence. This sequence may then be admixed with known

sequences to produce a pseudoheteroplasmy sample.



Representation of DNA structure

MILESTONES: In FY-00, a mitochondrial DNA (mtDNA) standard reference material (SRM) will be issued.

Federal Forensic DNA Laboratory Enhancement Grant Evaluation

The Forensic DNA Laboratory Improvement Program was authorized by the "DNA Identification Act of 1994" [Public Law 103-322]. The purpose of the program is to increase the capabilities and capacity of state and local forensic laboratories in the United States to conduct DNA testing. DNA testing supports criminal investigations involving the identification or exclusion of putative suspects by analyzing biological evidence recovered from crime scenes. Similarly, the State Identification System program (SIS) and the BYRNE Grant Formula Program have supported state and local forensic laboratory improvements.

NIJ oversees these grant-making programs. OLES supports NIJ in these efforts by funding research and development projects at the Chemical Sciences and Technology Laboratory (CSTL) at NIST. CSTL develops national DNA Standard Reference Materials (SRMs) to support measurement needs and also provides assessment of DNA laboratory performance in new technologies through interlaboratory testing. As part of its ongoing support of NIJ, OLES is doing an evaluation

of the effectiveness and impact of those programs.

MILESTONES: *Complete pre-testing the phase-1 web-based assessment instrument & launch the phase-1 assessment.*

Standard Reference Materials for Bullets and Casings

Under this project, final prototypes, designs, and manufacturing plans for standard reference materials (SRMs) for bullets and casings will be developed. These SRMs will be used for the validation of image analysis systems for ballistics identification.

As with fingerprints, every firearm has unique characteristics that leave unique signatures on the bullets and casings that it fires. By analyzing these ballistics signatures, examiners can connect a firearm to one or more criminal acts. The Integrated Ballistics Identification System (IBIS) and DRUGFIRE System have been proven extremely effective as automated tools for this process. Both types of systems use techniques of image capture, image analysis, and electronic databases. However, to demonstrate completely the reliability of these types of systems, a high quality measurement standard is required. Its key properties include uniformity, reproducibility, and stability. It will serve as a check standard to demonstrate the operation of these systems from day to day as well as the consistency between systems.

Thus far, a set of standard bullet prototypes have been designed, fabricated, and tested on several ballistics measurement systems (three IBIS and one prototype DRUGFIRE system). The results for repeatability, reproducibility, uniformity, and stability are very promising and the specimens have been universally judged to be an important tool for controlling the quality of measurements made with these systems. The design of the prototype casings has been completed and the fabrication of the prototype casings has begun. The following tasks are planned for this fiscal year.

- Fabricate a refined set of prototype bullets with improved shape for ease of use and with multiple surface signatures.
- Measure the refined prototype bullets by profiling techniques, and test the bullets on the IBIS and DRUGFIRE systems for repeatability, reproducibility, uniformity, and consistency between specimens.

- Test the prototype casings on the IBIS and DRUGFIRE systems for repeatability, reproducibility, uniformity, and consistency between replicas, as well as consistency between replicas and masters.
- Develop final designs and manufacturing plans for a set of SRMs for both bullets and casings.

MILESTONES: *In FY-00, the results of the above tasks will be documented in a final report. Final designs and manufacturing plans for a set of SRMs for both bullets and casings will be completed.*

On-Line Chemical Analysis of Human Hair Samples

The value of analytical chemistry to forensics is dependent upon a number of factors, including the sensitivity of the analytical technique for the analytes of interest, as well as the type of information obtained from a method's application to a forensic sample. Hair and fiber samples collected at a crime scene are typically characterized for their morphology by microscopic techniques. On occasions when the hair sample contains a root, genetic material can be extracted and characterized. This is generally the extent of the chemical information that can presently be obtained from a small hair sample. We have developed a method for determining the extractable components from hair using an on-line supercritical fluid extraction-gas chromatography/mass spectrometric (SFE-GC/MS) technique. This technique allows for all of the organic extractable material from a small hair sample (30 g to 100 g, typically a single segment) to be introduced into the analytical system, compared with only a few percent of the total from a conventional liquid solvent extract. The added sensitivity of the on-line technique (50 to 100 times the conventional extraction technique) enables full-scan mass spectra to be obtained from any peak detected in the extract, aiding in any confirmatory identification of the component. Our preliminary results suggest that hair from different individuals yields different chemical profiles, the sources of which include naturally deposited components (from sebaceous and sweat glands), artificially deposited species (from conditioners and treatment) and environmental contaminants (e.g., occupational exposure). Regardless of the source of specific components detected in a hair extract, the compounds could serve to distinguish individuals.

Our previous work of on-line SFE-GC/MS of hair samples employed the MS detector in scan mode so that we could measure as many chemical species as possible in the hair extracts. For measuring trace-level species in hair, it would be necessary to operate the MS detector in selected ion monitoring (SIM) mode, whereby a small number of ions, specific to target analytes would be monitored during an SFE-GC/MS analysis.

MILESTONES: In FY-00, statistical techniques will be applied to SFE-GC/MS data of hair samples to determine the ability of this type of analysis to discriminate forensic hair samples. Trace levels of steroids from intact hairs (not hydrolyzed) will be measured by SIM MS in order to add gender descriptive data to existing chemical profiles determined by the MS detector under scan conditions.

Development of an International Automotive Paint Database

This objective of this project is to develop an International Automotive Paint database which has forensic science applications to insurance industry investigations and law enforcement.

The Royal Canadian Mounted Police (RCMP) automotive paint database has, through a partnership with the FBI, become an important forensic trace evidence tool in North America. A Cooperative Agreement for Research and Development (CARD) between the RCMP and the FBI and funded by OLES has provided the resources needed to develop the database over a five year period. The goals included keeping Paint Data Queries (PDQ) current with the production year for the North American automotive industry and training all North American law enforcement agencies in the use of the database. As it grows, PDQ will enable:

- examiners to potentially identify make, model, and year of vehicles used in the commission of a crime or involved in a hit and run fatality;
- examiners to develop court testimony to provide the court with alternatives to an "either/or" type conclusion ("It is either the suspect vehicle or vehicles X as determined by PDQ.")
- paint analysts to be on the cutting edge of automotive paint technology (PDQ as a learning tool).

At the time that the present CARD was developed, we believed that we would require five years to achieve our goal of developing and implementing PDQ as a viable forensic

tool for all North American law enforcement agencies. This relied upon the addition of 1000 new samples a year to the database, to be supplied by the RCMP, the FBI, and other North American forensic laboratories.

MILESTONES: In FY-00: 1) Add 1500 new samples to the PDQ; 2) Train 16 new state and federal laboratories in the use of PDQ at the FBI Academy at Quantico, Virginia; and 3) Add additional programming improvements to individualize submissions from each state laboratory so that queries to the database could be customized and thus carry more investigative and judicial impact.

Multiplex (Single Nucleotide Polymorphism) SNP Research Research Project

The primary goal of this work is to produce a product that forensic laboratories and DNA database laboratories can use for high-throughput DNA analysis. This will involve the development of methods for robotic sample preparation and coupled DNA extraction procedures.

Specific tasks under this project are to:

1. Produce and test a set of single nucleotide polymorphism (SNP) probes for (mitochondrial DNA) mtDNA using known "hot spots" in the control region. Examine primers with degenerate positions and the ability to test closely spaced polymorphisms with short sequencing reads.
2. Develop software for multiplex SNP analysis and data interpretation. Work to expand the number of multiplexed SNP probes examined in a single mtDNA assay to 10 or more SNP sites.
3. Examine individual biallelic Y-chromosome SNP markers.
4. Develop multiplex polymerase chain reaction (PCR) and multiplex SNP probes for biallelic Y-chromosome SNP loci and implement the analysis software.
5. Determine the discriminatory power for the Y-chromosome marker set by analyzing a data set large enough to make critical statistical evaluations.

The sample processing steps will be refined, using a commercial mass spectrometer and robotic equipment. New MALDI DNA matrices will also be examined for improved performance.

Multiplex PCR and SNP steps will be optimized and tested extensively for robustness. A large number of samples will be run to validate the usefulness of the Y chromosome and mtDNA markers.

Work will also start on sequencing newly discovered STR microvariants and reporting these sequences in STRBase.

MILESTONES: *In FY-00, select a robotic system and integrate it with the mass spectrometer.*

Revision of ASCLD/LAB Accreditation Manual to Conform with ISO Guidelines

The American Society of Crime Laboratory Directors/ Laboratory Accreditation Board (ASCLD/LAB) operates an accreditation program for crime laboratories with members consisting of 139 domestic and 14 foreign laboratories. The board administers this program on a minimal budget from member dues and has only one part-time paid employee. The work of performing laboratory audits and reviewing audit reports for accreditation is performed on a voluntary basis.

The objective of this effort is to improve the quality of laboratory services provided to the criminal justice system by revising the policies and procedures of the board of the American Society of Crime Laboratory Directors/Laboratory Accreditation Board (ASCLD/LAB) to meet applicable international standards.

MILESTONES: *In FY-00 revisions to the current ASCLD/LAB Accreditation Manual will be proposed. An Operations Manual for the ASCLD/LAB board will also be proposed. Recommendations to change the bylaws of ASCLD/LAB so that they conform to the criteria in ISO Guides 25 and 58 will be made.*

Accomplishments

■ *The results of two recent workshops of forensic experts hosted by OLES are reported in NIJ Report 600-98, "Forensic Sciences: Status and Needs." As demands on the nation's crime labs escalate in response to technological advances and new legal requirements for processing evidence, many forensic scientists face a critical deficiency of essential reference materials needed to perform their jobs. The recommendations from these workshops will help to establish*

priorities so that national forensic community needs can be met.

■ *The methods and validation procedures for twelve chemical spot tests for use in the laboratory or in the field were established for the identification of unknown drugs. Chemical spot tests are valuable tools for the presumptive identification of unknown drugs. These tests are very sensitive with low detection limits, depending on the test and analyte. Reference colors from the Munsell Color Charts, representing positive reactions for the twelve chemical spot test reagents were included. This work will be published as NIJ Standard-0604.01, "Color Test/Reagents for Preliminary Identification of drugs of Abuse."*

Publications

NIJ Report 600-98, "Forensic Sciences: Status and Needs," February 1999.

NIJ Report 601-98, "Evaluation of Analytical Methodologies for Non-Intrusive Drug Testing: Supercritical Fluid Extraction of Cocaine from Hair," December 1998.

"Survey Tool for the Measurement of Workload in Crime Laboratories," January 1999.

NIJ Report 600-99, "Trace Evidence Analysis of Human Hair by On-Line Supercritical Fluid Extraction - Gas Chromatography/Mass Spectrometry: A Feasibility Study," approved for publication July 1999.

"Comparing the Additive Composition of Smokeless Gunpowder and Handgun-fired Residues," to be published in the Journal of Forensic Sciences.

"Correlation of Saliva Codeine Concentrations with Plasma Concentrations," Journal of Analytical Toxicology, Vol. 23, October 1999.

"Validation of Twelve Chemical Spot Tests for Detection of Drugs of Abuse," submitted for publication.

"Investigation and Forensic Science Technologies," SPIE Volume 3576, Law Enforcement and Securities Technology Conference (November 1998), Boston, MA (K. Higgins, ed.).

NIJ Standard-0604.01, "Color Test Reagents for Preliminary Identification of Drugs of Abuse," submitted to NIJ for Publication.

Public Safety Communication Standards

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Funding Sources:

100% Other Government
Agencies

Project Champions:

- Institute for Telecommunication Sciences, the research and engineering branch of the National Telecommunications and Information Administration (NTIA), Boulder, CO

Project Goals

The objective of this program is to lead the development of wireless telecommunications and information technology standards, profiles, and guidelines for interoperability, and information sharing, among criminal justice (CJ) and public safety (PS) agencies at state, local, and federal levels. To achieve this it will be necessary to focus on enabling technologies and open architecture standards so that interoperability approaches can be designed and implemented. Proposed techniques and standardized configurations will be verified and validated through simulations and laboratory testing.

Customer Needs

Law enforcement work requires effective coordination, communication, and sharing of information with numerous criminal justice and public safety agencies. Thousands of incidents that require mutual aid and coordinated response happen each and every day. High-profile incidents, such as bombings or plane crashes, test the ability of public safety service organizations to mount well-coordinated responses. In an era where technology can bring news, current events, and entertainment to the farthest reaches of the world, many police officers, firefighters, and emergency medical service personnel cannot communicate with each other during routine operations or major emergencies, such as the Oklahoma City bombing. New technologies are promoting the convergence of information and communication systems with the result that portable and mobile units are increasingly being viewed as merely wireless nodes within information networks. Interoperability, the ability of two or more organizations to communicate and share information (voice, data, images, and video) is therefore becoming more difficult.

To illustrate this point, one need only look at the existing environment of the public safety community. There are more than 17,000 law enforcement agencies in the United States. Approximately 95 % of these agencies employ fewer than 100 sworn officers. Additionally,

over 35,000 fire and emergency medical agencies exist across the nation. Due to the fragmented nature of this community, most public safety communications systems are stovepipe systems that do not facilitate interoperability. Additionally, public safety radio frequencies are distributed across four isolated frequency bands from low band VHF (25 MHz to 50 MHz) to 800 MHz (806 MHz to 869 MHz), with no universally-available or affordable radio being able to operate across the entire range.



Effective communication is a critical aspect of both law enforcement and corrections operations. Dispatch is the nerve center of the agency.

Technical Strategy

There are two main project areas associated with the Standardization Program -- one related to Telecommunications (primarily wireless) interoperability, and the other addressing information sharing thorough Information Technology (IT)/ Information System (IS) applications. In both project areas, there are two primary elements:

1. Direct work efforts that involve the definition of criminal justice and public safety requirements across local, State, and federal boundaries, and the adoption of standards to satisfy those requirements, and
2. Coordination with other organizations that are involved in related activities in order to ensure successful standardization results for all. For example, participation in the activities of such organizations as: the Public Safety Wireless Network (PSWN), Federal Law Enforcement Wireless Users' Group (FLEWUG), Project 25, Federal Communications Commission's (FCC's) Public Safety Forum, National Public Safety

Telecommunications Council (NPSTC), the FCC's Public Safety National Coordination Committee (NCC), the National Telecommunications and Information Administration's (NTIA's) Public Safety Program, and other bodies related to the interoperation and/or standardization of IT and telecommunications for the criminal justice and public safety communities.

These elements permeate a number of technical tasks, which are the logical and necessary steps to the successful conclusion of both the telecommunications and IT thrusts. The tasks are summarized below. In some cases, these FY-00 project tasks build upon activities begun during FY-99.

Since user requirements are key to any standardization effort, the first task is to identify criminal justice and public safety user organizations that have identified user requirements for IT and telecommunications, and/or who have identified shared-information requirements. Similarly, it is necessary to identify industry trade or user organizations that have identified user requirements for IT and telecommunications, and/or who have identified shared-information requirements. Although these groups are not focused on criminal justice and public safety applications, their overall missions may include operational requirements that are very relevant to CJ and PS. Next, identify and analyze all of the requirements from the organizations identified, and develop a dynamic database. Maintain a historical context for all requirements entered into the database.

Because it is prudent (and efficient) to take advantage of good work already accomplished in the standards arena, the next task is to identify and characterize Standards Development Organizations (SDOs) that are involved in telecommunications and IT-related efforts. Similarly, Standards Related Organizations (SROs) need to be identified and characterized. Since the SROs have historically been established to address new technologies, or applications for new technologies, it is expected that several SROs will arise between now and FY-01. For all SDOs and SROs, there will be a continuing effort to list their respective standards, specifications, or agreements, and any ongoing

efforts in the SDOs/SROs that should yield new and relevant standards, specifications, and agreements.

The identification and compilation of formal documents that are associated with standards activities is a huge task. It is estimated that telecommunications and IT standards may already number between 5,000 and 10,000 documents. In addition, there are some 1,200 active SRO specifications/agreements that may find their way to becoming formal standards. The Internet Engineering Task Force (IETF) alone has some 450 documents that specify the Internet and its operations.

In order to expedite standardization of IT interoperability (and IT mobility, i.e., wireless access to the IT network framework), the IETF documents will be reviewed and analyzed as a good starting point. Even with 450 documents, however, it is fairly certain that they will not provide the necessary characterization of virtual private networks (VPNs), multi-level security techniques, and transfer mechanisms required for criminal justice or public safety operations. New documents will need to be developed and offered to the IETF and the SDOs for review and adoption. (The development of standards documents for the SDOs/SROs is explained further below.)

In order to keep the CJ and PS apprised of ongoing standardization efforts, and to validate the products being developed by OLES, IT and telecommunications focus groups will be convened with attendance by recognized officials from the criminal justice and public safety communities. At the same time, subcommittees of technical experts will be organized and convened to confront detailed technical issues that arose during higher-level focus group discussions. Agendas, discussion points, white papers, and other aids will be developed that can be used to structure and advance the work of the focus groups and subcommittees.

Another task will be to analyze the available (and emerging) IT and telecommunications standards and SRO specifications and agreements for applicability to satisfying the needs of the criminal justice and public safety communities. The salient characteristics of the standards and agreements, and the results of the analysis for each will then be documented. Furthermore, it will be necessary to harmonize

the diversified requirements of the (wireless) telecommunications users with those of the (wireline) information technology users to ensure that all end-to-end system interoperability issues are adequately addressed, including performance. As potential interoperability approaches are derived, simulations and/or laboratory testing may be needed to assess the viability and effectiveness of the schemes.



The ability of an officer to communicate other local agencies and emergency responders is critical to efficient and safe operations.

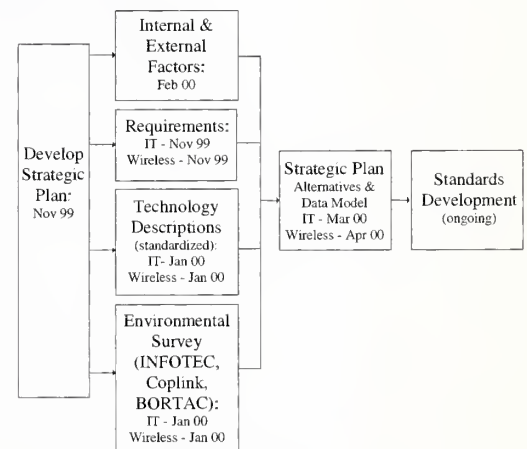
A mechanism and/or procedure for formally considering standards for adoption by the criminal justice and public safety communities will be established and maintained. After receiving approval of the overall methodology and specific operational steps, the process will be documented and disseminated to all parties concerned. OLES will act as the Secretariat for the standards organization during its operation. NIJ Standards will be adopted. Where necessary, standard profiles will be developed and adopted to further define the particular technical specifications of the standards that are implemented. It will be required, then, to construct and maintain a relational database containing lists of adopted standards and their profiles, as well as the actual documents.

A critical task will be focused on filling in the gaps where users' requirements are not currently addressed by ongoing SDO and SRO activity. That is, standards will be developed by working through the appropriate SDOs/SROs. Since the needed standards will cover a tremendous breadth of technical areas, this effort includes several parallel efforts performed by numerous subject area experts. After concentrated efforts on numerous fronts,

and adoption of standards and specifications by SDO/SROs, there will be processing and adoption of the approved SDO/SRO standards as NIJ Standards.

Finally this project will establish and maintain entire sets of IT and telecommunications interoperability standards that can be made widely available to the criminal justice and public safety communities via Internet (or some other transfer mechanism with ubiquitous access to local, state, and federal agencies). To ensure the integrity and completeness of the interoperability standards, it will be necessary to monitor new technologies, and user requirements, on an ongoing basis. It will also be required to coordinate closely with local, state, and federal IT and telecommunications users' organizations that are constantly addressing criminal justice and public safety applications. Information from all relevant organizations can then be utilized, with new areas for standardization being assimilated into the overall project effort.

MILESTONES: In FY-00, program efforts will include an expanded role in leading efforts in the Advanced Generation of Interoperability for Law Enforcement (AGILE) project relative to the identification and adoption of interoperability standards. The following flowchart shows the general activities that will take place during FY-00.



Accomplishments

- Published NIJ Guide 200-98, "New Technology Batteries Guide," October 1998. Batteries, primarily for communications equipment, are a major expense for all police departments. This guide, prepared for the law enforcement community, provides an introduction to battery fundamentals, types,

performance and economic tradeoffs, selection criteria, handling and maintenance.

■ *Submitted NIJ Guide 201-99, "Video Surveillance Equipment Selection and Application Guide," to NIJ sponsor for publication.* This guide educates law enforcement and corrections agencies in the cost-effective and application-specific selection of video surveillance equipment. The guide pays particular attention to delineating the technical parameters that most influence operational performance of video gear used by police to collect evidence or provide safety.

■ *Provided final draft of NIJ Guide 202-99, "Antenna System Guide," to NIJ sponsor for approval.* In this guide, the reader is provided with sufficient understanding of the fundamentals, characteristics and functions of antennas to enable him or her to develop requirements and discuss antennas with vendors, installers, repair shops and others. This information is generally restricted to the kind of antenna systems used by law enforcement agencies.

Publications

NIJ Guide 200-98, "New Technology Batteries Guide," October 1998.

NIJ Guide 201-99, "Video Surveillance Equipment Selection and Application Guide," in print.

NIJ Guide 202-99, "Antenna System Guide," under review.

Office of Law Enforcement Standards Organization (810.02)

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